# ESSENTIALS OF ORTHOPÆDICS

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By


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# PREFACE

NICOLAS ANDRY, in 1741, wrote a book which he called *L'Orthopédie*
use it was about the problems of "straightening children," and the
n has remained in use ever since. It is, however, an imperfect descrip-
of the work of the present-day orthopaedic surgeon as this includes
liseases and injuries of bones and joints, and of the muscles and nerves
trolling them. The field has become so vast, even when fractures are
luded, and much is so specialized, that no single volume could cover
aspects. I have, therefore, endeavoured to explain as simply as possible
physiological and pathological basis of orthopædics and its application
liagnosis and treatment. The increasing appreciation of the importance
posture has made it desirable to pay special attention to this subject.

I have had in mind primarily the needs of the general practitioner
o has to advise the patient in the first instance, the undergradua e
dent who requires classified information to help him order his thoughts,
l the postgraduate who is beginning his surgical training. A regional
angement is used in order to assist with diagnosis, and when a disease
urs at several sites, the pathology is considered either with the region at
ich it is most common or in a separate chapter. Treatment is described
detail when it can be carried out by a general practitioner; in other
es the available methods of treatment and the probable functional
ults are discussed, operative procedures being described only in general
ms.

The foundations of modern orthopædic surgery were laid less than a
neration ago by a small band of pioneers, and between these men was
rmed a bond of fellowship that knew no international boundaries. We
e proud that now, when orthopædic surgeons are numbered by thousands
stead of by tens, this fellowship remains and there is still the free-est
terchange of ideas and experiences between one surgeon and another,
d one country and another. It is well that this is so because orthopædics
still in its infancy and there is hardly a procedure that is universally
cepted as "best," or that someone, somewhere is not trying to improve.
rogress has been particularly rapid in the U.S.A. during the last decade,
d in spite of difficulties in communication during the war, many of the
ew developments have been adopted by British surgeons. There remain,
owever, a few major differences in the current practice of the two
ountries, and this is a healthy sign of the mutual criticism that is not only
olerated, but encouraged.

Orthopædics differs from other branches of surgery in that it deals
hiefly with injuries and diseases that are potentially crippling. The major
ole in treatment has often to be played by the patient who alone can

prevent his joints from becoming stiff and his muscles from wasting. It is, therefore, essential to have the whole-hearted co-operation of the patient and, equally important, the help of a team consisting of nurse, physiotherapist and social worker to stimulate and direct his efforts. The purpose of operation is to make it possible for the patient to do his share of the work; it is but an incident in the course of treatment, and if its part is over-emphasized in the written account, it is because it would be tedious to repeat the other aspects continually even though they are just as important.

PHILIP WILES

LONDON

# ACKNOWLEDGEMENTS

A surgeon's knowledge derives from the experience of his teachers and his contemporaries, and although it is tempered by his own observations, he can claim comparatively little as original. It is to the teachers who directed his first approach to the study of disease that he owes most and I cannot adequately express my gratitude to Sir Gordon Gordon-Taylor who introduced me to surgery, and to Lord Webb-Johnson whom I was privileged to serve for three years as first assistant, for the part they played in my surgical education. It was my good fortune to be apprenticed in orthopaedic surgery to Mr. A. S. B. Bankart and I worked with him for so long, and he taught me so much of what I now practise, that I must ask him to accept this general acknowledgement for the many ideas that he will recognize as his own.

I have been very fortunate in the kindness of some of my friends on the staffs of London Teaching Hospitals—Mr. B. H. Burns, Mr. H. J. Burrows, Mr. St. J. D. Buxton, Mr. H. Osmond-Clarke, Mr. V. H. Ellis, Mr. P. H. Newman and Prof. R. W. Scarff—who have given so freely of their time and between them have read the entire manuscript and made many valuable suggestions and criticisms. Whilst of course I must accept full responsibility for the whole book, it is true to say that all their suggestions have been accepted and this must add authority to the text.

I have drawn freely on the generosity of my colleagues for the supply of illustrations—many of my own hospital records were destroyed during the war—and it is with great pleasure that I thank Mr. St. J. D. Buxton for Fig. 317, Mr. J. A. Cholmeley for Figs. 63 and 95, Mr. W. D. Coltart for Fig. 348, Mr. F. C. Durbin for Fig. 96, Sir H. A. T. Fairbank for Fig. 350, Dr. Ali Mohammed for Fig. 291, Mr. P. H. Newman for Figs. 272, 274 and 364, Mr. K. I. Nissen for Fig. 170, Prof. R. W. Scarff for Fig. 249, Prof. H. J. Seddon for Figs. 80, 81, 82, 101, 110, 154, 155, 256, 294, 295, 296, 298, 325 and 362, Sir R. Watson-Jones for Figs. 72 and 343, and Prof. B. W. Windeyer for Fig. 342. Dr. Graham Hodgson very kindly allowed me to make use of the radiological museum at the Middlesex Hospital and Dr. C. G. Whiteside has taken endless trouble over the search for films. I have also to thank the President and Council of the Royal College of Surgeons of England for permission to have reproductions made of specimens in the museum of the College for Figs. 281, 337 and 338, Prof. E. D. Telford for permission to redraw Figs. 218 and 219, Prof. F. Wood-Jones to redraw Figs. 206 and 207, and to the Editor of the *Lancet* to republish Figs. 6, 7, 10, 11, 15 and 16. I am indebted for the loan of blocks for Figs. 107 and 177 to Mr. B. H. Burns, Mr. V. H. Ellis and the publishers of Recent Advances in Orthopaedic Surgery, for Fig. 106 to Dr. Campbell

Golding and the Editor of the *Journal of Bone and Joint Surgery*, and for Fig. 2 to Messrs. Down Bros. Ltd.

Finally, I wish to express my appreciation of the skill and patience that Miss B. E. Nicholson has devoted to making the line drawings and coloured illustrations, and the care with which Mr. P. H. Newman and Mr. Ross Bloom have corrected the proofs.

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CHAPTER I

# POSTURAL DEFECTS

POSTURAL defects are variations from the accepted "normal" posture which can be corrected by the active effort of the patient. It is seldom that one part of the body alone is involved and usually the entire posture is at fault: for example, valgus feet are found more frequently in association with abnormalities of the antero-posterior curves of the spine than as an isolated occurrence. The inter-dependence of defects of different parts of the body will be emphasized as much as possible although they have to be separated for systematic description, and when considering treatment it is particularly important to view the patient as a whole because a single fault cannot be corrected alone.

There are several minor structural abnormalities that are so commonly associated with postural defects as to be inseparable, and therefore they will be described in this chapter. They include slight wedging of the lower dorsal and upper lumbar vertebræ (dorsolumbar kyphosis), torsional deformities of the tibiæ, and obliquity of the lower articular surfaces of the tibiæ. Knock knee and bow legs are also included because they are often caused by a minor irregularity in growth or faulty posture.

## Physiology

The posture of the body at any given moment depends on the position of the joints and thus is controlled by the skeletal muscles. The part played by the ligaments in maintaining posture is a subject of controversy. It is argued by some that the strength, structure and arrangement of the ligaments make it obvious that it must be an important part. On the other hand it is clear that in the ordinary upright position no ligaments are under tension because every joint is at an intermediate point in its range of movement and can be moved in all directions. Ligaments are so nearly inextensible that, if they were taut, movement would be impossible in at least one direction. Moreover continued strain on ligaments is painful, as everyone is aware from the pain felt behind the knees after resting the feet for some time on the opposite seat in a railway carriage. For these reasons ligaments can play no direct part in holding the upright position. Their function is complementary to that of the muscles; the muscles cause movements and maintain posture within the ordinary range, whereas the ligaments limit the extremes of movement and take the strain when the muscles are fatigued or overloaded.

The apparent paradox that muscles both cause movement and prevent it is not difficult to explain. When a muscle fibre is stimulated it develops within itself a state of tension and its subsequent behaviour depends on conditions external to it. If there is no resistance, the fibre contracts and causes movement; if there is resistance which it is unable to overcome, movement is absent or minimal and the contraction is said to be "isometric" The former process is used in making movements, the latter in maintaining posture. Individual fibres follow the "all or none" law and therefore the power exerted by a contracting muscle is proportionate to the number of fibres in action. This in turn depends on the external resistance to be overcome and the rapidity of movement. For the maintenance of posture, the number of fibres in use simultaneously is small and there is a continual change of contracting fibres which reduces fatigue to a minimum (Fig. 1).

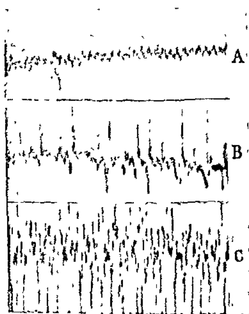



Fig 1 Electromyogram of gluteus medius muscle Intramuscular electrode
A At rest
B Standing on both legs
C Standing on one leg

The process of maintaining posture requires the balanced contraction of the muscles on each side of the joint concerned, and in the upright position nearly every joint and muscle in the body is involved. The regulation of this complicated process is carried out by the central nervous system which co-ordinates afferent impulses from the muscles, eyes, ears and skin with efferent motor discharges. A permanent change in habitual posture is *not* effected by the muscles on one side of a joint contracting more strongly, and those on the other side less strongly; this process only causes the movement by which the new posture is reached. To hold the new posture the muscles have to remain at a different length, and the power required is not necessarily greater than before. To keep *the muscles habitually at this different length is a function of the central* nervous system and it involves the conditioning of a new reflex which regards the new muscle length as normal

## Normal Posture

The posture of different individuals varies within wide limits according to body build, habits and occupation: moreover posture is as much an expression of personality as the gestures of the hands. There is no normal posture any more than there is a normal body weight, and the concept of an average posture, a mathematical mean of all postures, is valueless. We can only describe certain outstanding features, some of which can be measured, and make allowance for individual variations. The finer points that go to make a good "carriage," such as the poise of the head and neck, are too elusive for mensuration and the final assessment must remain to some extent a matter of personal judgment and experience. The printed silhouettes showing "normal" posture that are sometimes displayed should be interpreted with indulgence.

The posture of the hip joint is the key to that of the whole body because it determines (*a*) the inclination of the pelvis, and the pelvis is the foundation upon which the spinal column is erected, and (*b*) the rotation of the legs and therefore the posture of the feet (p. 19).

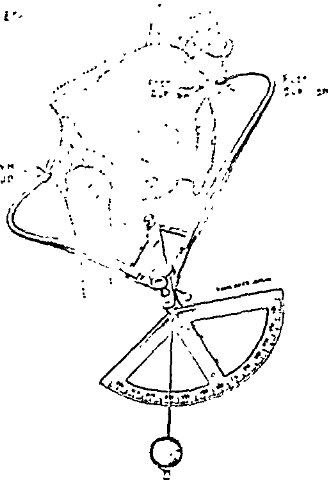


Fig. 2 Pelvic Inclinometer.

The pelvis is irregular in shape and there is no general agreement as to the selection of points to indicate its inclination. Various suggestions have been made but none readily give the plane either of the pelvic brim or of the upper surface of the sacrum. For the present purpose it does not matter what plane is used because it is required only for comparative purposes. The following method of measuring the pelvic inclination uses arbitary points selected chiefly because they are easily palpable, and it is rapid and sufficiently accurate. The points used are the upper border of the symphysis pubis and the posterior superior spines of the ilium; one blade of the inclinometer is placed on a mark made in the mid-line at the level of the posterior superior spines, the other is placed on the upper border of [illegible] o make the plumb-bob parallel w[illegible] 2).

The [illegible] averages 31° in males

and 28° in females. Variations up to 4° on each side of the average is within the "normal" range. The pelvis is more horizontal in infants and the inclination increases steadily with growth ; at four years of age it is about 22° in both sexes, and at seven years 25°. The adult angle is reached about the tenth or eleventh year and then the variation due to sex first appears.



FIG 3 The posture of young adults

Another postural feature that can be measured is the relation of the large joints to a vertical line passing through the mastoid process. This corresponds approximately to the plane of the centre of gravity of the body and it normally passes through the middle of the shoulder and hip joints, towards the front of the knees and well in front of the ankles (Fig. 3). Deviation from this alignment occurs in certain postural defects.

## Ætiology

The causes which lead to the development of faulty postural reflexes, or to a change from good to faulty reflexes, are not fully understood. Postural defects tend to develop during periods of rapid growth because the bones and muscles are then increasing in length and therefore the postural reflexes are continually being adjusted. Failure to adjust properly may be due to an upset in general well-being such as occurs in an undernourished child, or when there is toxæmia due to chronic infection. In many patients, however, there is evidence of emotional maladjustment.

It is obvious that the posture is subject to conscious modification, and by analogy it might be expected to be influenced also by unconscious cerebral processes. The investigation of this subject is fraught with the greatest difficulty and there are many pitfalls in the way of the interpretation of any findings, but sometimes it does seem possible to make a direct correlation between the psychological findings and the physical condition.

The most extreme example of the association of an abnormal psychological state with an abnormal posture is seen in "neurasthenia," using the word in the narrow sense of a particular functional nervous disorder. The picture in both adults and children is distinctive. The patient is flabby in mind and body; mentally he is tired, bodily he has given way to gravity and has a sagging jaw and drooping eyelids, rounded shoulders, a tilted pelvis and flat feet. The mental and physical condition go together and any attempt to change the physical condition until such time as the psychological adjustment has been improved leads to disappointment.

There are other less clearly defined groups. In the "anxiety state" the general picture is of a hypersensitive, alarmed child, not infrequently subject to nightmares and sometimes with a stammer. Physically he tends to have valgus feet, knock-knees, and round shoulders - a position of fear but in contrast with the "neurasthenic" his muscles are tense rather than slack. Again, the "obsessional" child may have queer habits of gait and posture, often asymmetrical, which are impossible to explain except in association with the psychological condition. Most patients do not show so extreme a picture, nor is the correlation between the physical and psychological findings always so obvious and it may only be found after expert investigation of both the patient and his environment.

Children have much to learn and tend to concentrate on one aspect of life at a time. Whilst a young child is busily enquiring about the many phenomena surrounding him, and being well satisfied with the mobility given by his recently acquired powers of locomotion, he may lose interest in the way his body functions. But at a later period, perhaps when games are interesting him, he will all unconsciously attend to the defects of the body that may have developed meanwhile. Girls in their early teens frequently stand badly and are ungainly in their movements, and it is noticeable that the age at which they correct themselves often corresponds with the first display of real interest in the other sex.

It has been customary for many years to lay the blame for some postural defects, and indeed for gross deformities, on the immediate surroundings of the child, such as vicious school furniture, and the type of clothing. The older textbooks contain some delightful woodcuts showing, for example, a child with a severe scoliosis playing the violin, and a schoolgirl slouching over a badly designed desk with her head resting on her hand. It is naively assumed that these figures illustrate the cause of the deformity, although no explanation of the mode of action is offered. It is difficult to believe that such factors are of great importance, a child who is going to sit badly will do so at any desk and it would be far more rational to blame a boring lesson which fails to hold his attention.

## ANTERO-POSTERIOR CURVES OF THE SPINE

The pelvic inclination is the most important single factor affecting the curves of the spine. The pelvis is the base upon which the spinal column is erected and therefore any change in its inclination must cause a corresponding change in the position of the fifth lumbar vertebra, and this in turn alters the posture of the whole spine.

The pelvis is balanced on the femora, hence its inclination is determined by the posture of the hips (Fig. 4). Control of the pelvic inclination is exerted ordinarily by the muscles surrounding the hip and only in unusual circumstances is it a function of the trunk muscles. The inclination is increased by contraction of the flexors of the hip, i.e. the ilio-psoas, rectus femoris and the more anterior portions of the adductors. It is decreased by the extensors, i.e. the glutei, hamstrings and posterior adductors. The three glutei function in one unit as part of the extensor group of muscles that maintain the upright position.

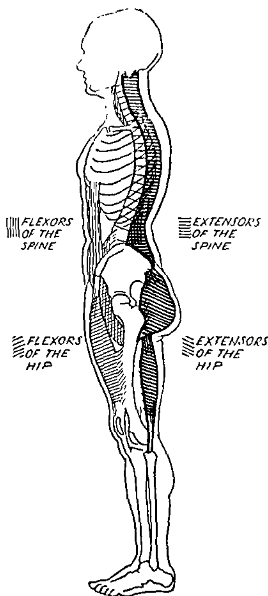


Fig. 4

Their combined unopposed action produces extension, abduction and external rotation of the hip joint, the thigh or pelvis being moved according to which is free; the thigh moves during locomotion, but the pelvis when standing. Postural increase in the length of the glutei allows the pelvis to tilt forwards and the legs to rotate inwards.

The spine is extended by the erector spinæ and flexed by the abdominal muscles. It is sometimes stated that contraction of the rectus abdominis reduces the pelvic inclination and patients are wrongly taught to use this muscle for the purpose. The rectus abdominis acts synergically with the glutei; the glutei reduce the pelvic inclination and the abdominals reduce the lumbar curve.

Movement of the spine is greatest in the lumbar region where there is a large and powerful muscle mass to raise the trunk from the flexed position. In the dorsal region rotation is considerable, but flexion and extension are

restricted. The dorsal spine, however, extends slightly but appreciably with every breath, and therefore the muscles of respiration, the diaphragm, intercostals, etc., have a secondary postural rôle.

**Dorsolumbar Kyphosis.** This is a localized form of adolescent kyphosis in which the bodies of the lower dorsal and upper lumbar vertebræ become slightly wedge-shaped (Fig. 5). The condition commonly accompanies certain postural defects and possibly is caused by them. The abnormal posture increases the stress on the anterior portions of the vertebral bodies and intervertebral discs, and this may interfere with their development, particularly in the dorsolumbar region where the change in curve from concave to convex makes it mechanically weaker (p. 74).



FIG. 5. Dorsolumbar kyphosis. There is wedging of the 11th and 12th dorsal and 1st lumbar vertebræ.

## Types of Defect

It is essential for the maintenance of the upright position that whatever abnormality of posture is present, the centre of gravity of the whole body is above the area occupied by the feet. This limits considerably the possibilities of postural variation. In the following descriptions it is assumed that the pelvic inclination alters first and then movements of the rest of the body are made afterwards to adjust the centre of gravity. This makes the mechanics clearer and is helpful in planning the details of treatment, but it is not the actual manner in which defects arise during life; the process is *one* of gradual "slumping" rather than separated movements.

Two components contribute to make up the majority of defects: (*a*) an increase or a decrease in the pelvic inclination, the former being the commoner, and (*b*) dorsolumbar kyphosis. These two variables combine to produce four distinct types which include the majority of defects.

*Increased pelvic inclination* plus *mobile spine* .......... *lumbar lordosis*
*Increased pelvic inclination* plus *dorsolumbar kyphosis* .... *sway back*
*Decreased pelvic inclination* plus *mobile spine* ........... *flat back*
*Decreased pelvic inclination* plus *dorsolumbar kyphosis* .... *round back*

**Lumbar Lordosis.** The mechanism of the production of lordosis can be visualized as follows: first the pelvis tilts forwards and with it the whole trunk, then the centre of gravity is restored to above the feet by bending backwards in the lumbar region thus increasing the concavity (Fig. 6b). There is often a general slump of the anti-gravity muscles permitting some [illegible] the dorsal curve, sagging at the shoulder girdles, internal [illegible] and valgus feet. The mastoid line bears much the same [illegible] the large joints in the corrected and uncorrected positions. [illegible] not marked and the appearance is very different from [illegible] is with compensatory lumbar lordosis (Fig. 53, p. 77).

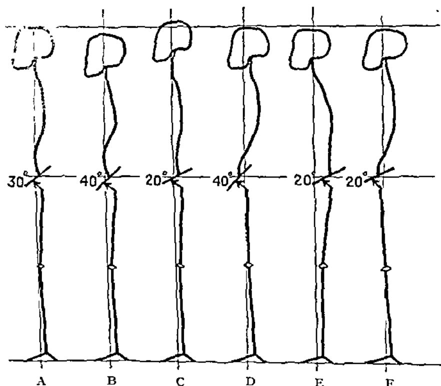



Fig. 6.
A. Normal B Lordosis C Flat back D Sway back E. Round back, type I. F. Round back, type II

The typical clinical picture is of a child with a tilted pelvis, increased lumbar curve, drooping shoulders, head poked forwards, internally rotated legs and valgus feet. The dominating feature is, however, the pelvis and the whole posture is immediately corrected by reducing the pelvic inclination (Fig. 7).

**Sway Back.** Forward tilting of the pelvis is associated with dorsolumbar kyphosis. The kyphosis is sometimes quite small, really no more than a little flattening of the upper part of the lumbar concavity; *even this amount, however, is sufficient to prevent the spine compensating*

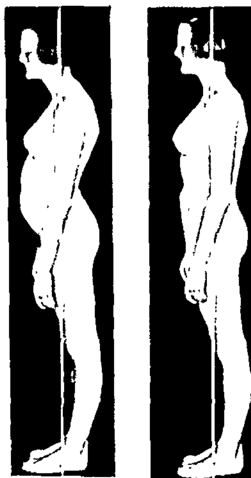


FIG. 7.
*Left*. Lordosis.
*Right* The posture is immediately corrected by reducing the pelvic inclination

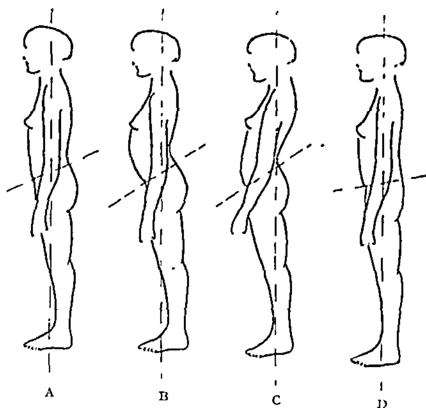



FIG. 8
A. Normal B. Lordosis. C. Sway back D Flat back

for the tilted pelvis by a general increase in the lumbar curve, as occurs in the previous type. Instead the spine is bent backwards rather sharply at the lumbosacral angle and the centre of gravity is stabilized by inclining the legs slightly forwards at the ankles so that the pelvis projects forwards (Figs. 6d and 9) The mastoid line passes well behind the great trochanters, and a plumb line from the most prominent part of the dorsal convexity falls behind the sacrum. There is also a general slump of the anti-gravity muscles with the associated drooping shoulders, internally rotated legs and valgus feet.

A very similar posture is often adopted temporarily when standing at rest with the weight mainly on one leg. In this position the ligaments of one hip and the lumbosacral joints are under tension and soon start aching. It used at one time to be rather a "fashionable" way of standing.

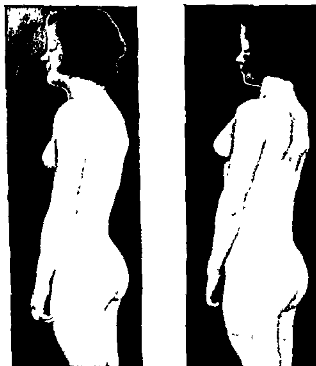


Fig 9 Sway back The posture is improved by reducing the pelvic inclination, but the dorso-lumbar kyphosis is more apparent

**Round Back.** This is a rather less clearly defined group in which a decreased pelvic inclination is associated with *dorsolumbar* kyphosis. The centre of gravity may be stabilized in two ways. In type 1, which gives the name to the group, the trunk is bent forwards in the lower lumbar region obliterating what is left of the lumbar curve. The legs are inclined slightly backwards and the great trochanters are behind the mastoid line (Figs. 6e and 10). The mechanism in type 2 is very similar to that in sway back. The legs are inclined forwards and the trunk backwards causing a low lumbar angulation, and the great trochanters are in front of the mastoid line (Figs. 6f and 11).

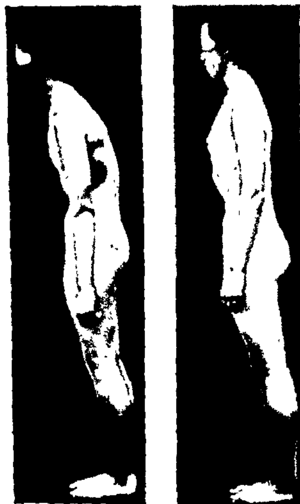


FIG. 10 Round back, type I In both types the posture is improved by increasing the pelvic inclination

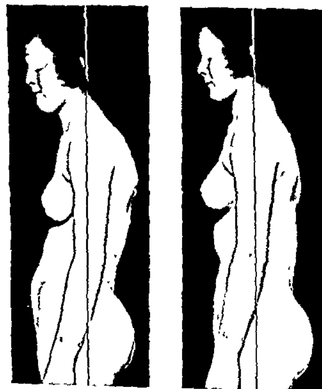


FIG. 11 Round back, type II.

[illegible] **Back.** This is just as much a deformity as an unduly curved [illegible] but less common. The pelvic inclination is reduced, and the lumbar spine is flattened in compensation, by a mechanism which is the reverse of that in lumbar lordosis (Fig. 6c and 8). Children with a reduced lumbar curve are often described as having a "lovely straight back" but the posture is not good. Such backs become stiff later in life causing intractible backache and therefore the posture should be corrected during childhood

**Round Shoulders.** This defect seldom exists alone as a clinical entity but constitutes part of a general postural defect. It occurs when the cervical and dorsal muscles suspending the scapulæ allow them to fall [illegible]wards and forwards under the influence of gravity in a direction [illegible]ed by the contour of the upper ribs. The effect is exaggerated by [illegible] increase in the dorsal curve which is usually present, and by [illegible]g the head and neck forwards.

Failure to recognize during treatment that round shoulders are only part of a more general defect leads to the assumption of that grotesque attitude, the old-fashioned "military position," which results from throwing out the chest, forcing back the shoulders and drawing in the chin without correcting the pelvic inclination.

## POSTURAL LATERAL CURVATURE

Postural lateral curvature is an entirely different condition from structural scoliosis and is a disorder in function of similar ætiology to other postural deformities. It is not associated with changes in the shape of the vertebræ and it can be fully corrected by voluntary effort. The older surgeons, who believed that scoliosis was often caused by occupational habits, concluded that postural lateral curvature was frequently transformed into a structural defect. It is, however, doubtful if this ever occurs, and in the rare instances when it appears to, it is probable that structural scoliosis has been seen at a very early stage before there are any radiological changes. The very word scoliosis has a serious significance in the minds of both laymen and doctors, and since postural lateral curvature has a different ætiology and a different prognosis, it is better not to classify it with scoliosis but to include it with postural defects where it properly belongs.

Lateral curvature which is completely or partly correctible also occurs when there is lateral tilting of the pelvis caused by disparity in the length of the lower limbs. Difference in length up to a third of an inch is of no significance and indeed it is not infrequently present without the patient being aware of it; the curvature produced is so slight as to be noticeable only on careful examination. It is further discussed with structural scoliosis on page 86.

Postural curvature occurs chiefly in adolescents, and in girls more often than boys (Fig. 12). There is a smooth curve without sharp angulation, and it is convex to the left more frequently than to the right. It

usually includes all the lumbar and dorsal vertebræ, the apex being in the mid- or lower dorsal region (total scoliosis). Rotation of the vertebræ, if any, is slight, and there is no deformity of the ribs.

The diagnosis depends on the absence of fixed deformity and the absence of radiological evidence of alteration in the shape of the vertebræ. The curve is abolished by flexion of the spine, by standing on one leg or by any similar movement that involves synergic contraction of the erector spinæ. It frequently, but not always, disappears when sitting, and when standing many patients can correct it by voluntary muscular effort. It is so important to distinguish postural curvature from early structural scoliosis that an X-ray should always be taken.

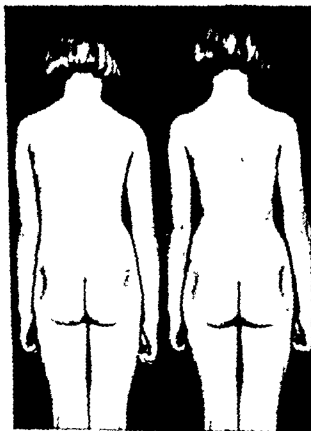


FIG 12 Postural curvature corrected by voluntary effort Note the apparent increase in height

The prognosis is excellent. It can be said with some certainty that a postural curve will correct itself, and it seldom persists into adult life. Adults with postural curvature are more likely to have acquired it freshly, and since then it is often the result of bodily or mental fatigue, attention should be directed to this.

The treatment of postural curvature is identical with that of other postural defects (p. 33) but correction is more simple and therefore remedial treatment is less important. The defect is often an indication that all is not well with the child's general health or emotional adjustment, but when these are satisfactory postural correction is easily achieved.

## THE FEET

### The Longitudinal Arches

The feet have the dual purpose of supporting the body in the static rôle of standing and propelling it forwards during locomotion. The human feet are constructed in a manner peculiar to man and are well suited to meet these demands. They are divided functionally into two parts, an inner part concerned principally with weight-bearing, and an outer concerned with stability and balance.

The way in which the feet carry out their static and supporting rôle is very clearly explained by Wood-Jones. He points out that the two feet together rather than a single foot is the unit of support. "We do not carry our body weight," he says, "on legs and feet that may justly be regarded as two columns of support. That is the way in which an elephant's weight is transmitted through columnar legs and feet. The human stance is, however, to be likened to the business of carrying the weight on two half columns rather than on two whole ones."* The prints of the two feet placed close together are approximately circular in shape and they enclose a nearly circular area without contact with the ground ; the slender-built outer part of the foot lies flat and gives stability and balance (Fig. 13). There is no real arch to the lateral side of the foot but the supporting bones, the calcaneus, the cuboid and the fourth and fifth metatarsals, are slightly bowed to give them spring. There is a fair range of vertical movements at the fourth and fifth tarso-metatarsal joints which materially assists in balancing.



Fig 13 The prints of the two feet show the area of support (Redrawn from Wood-Jones)

The inner side of the foot is of massive build suited to its heavy work of weight-bearing and propulsion. It has a very definite arched structure which is visible both in the outward appearance and in the internal arrangement of the trabeculæ of the bones. The arch is formed by the calcaneus, talus, navicular, the cuneiforms and the inner three metatarsals. The classical attempts to liken this arch to an architectural structure stimulated a lively controversy which has provided light entertainment over a period of years. Professor Wood-Jones has, perhaps, disposed of the simile finally in the book from which quotation has already been made. It is true that

* The Foot. Baillière, Tindall & Cox. London, 1944, page 244.

the arrangement of the bones does resemble a low arch but the surfaces of the joints are curved, unlike a masonry arch whose components have flat surfaces, and the foot collapses when the supporting muscles are removed. The shape of the joints is cunningly contrived to fulfil three purposes: it enables the bones to be held in the desired position with a minimum of muscular effort, it gives resiliance to absorb the enormous stresses to which the foot is subjected, and it makes provision for fatigue by permitting the arch to be "lowered" until the inner border of the foot rests on the ground.

There is no normal height for the arch, and much as a high-arched foot may be admired by some, a low arch can give equally satisfactory use to its possessor. The shape of the foot is subject to as much individual variation as any other part of the body. It may be long, short, fat, thin, broad or narrow in almost every combination, and just as there is an appropriate posture for every type of back which reduces stress to a minimum, so for every type of foot there is an appropriate posture. The foot is a supple structure with a fair range of movements and the height of the arch

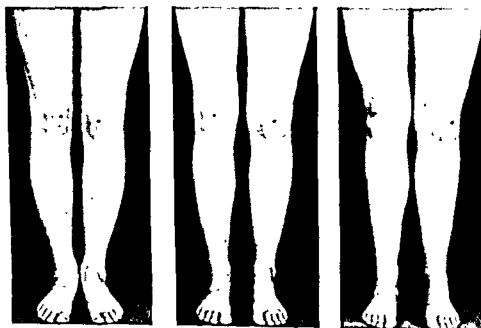


FIG 14 *Centre*—Habitual posture with the patellæ facing straight forwards
*Left*—Internal rotation of the legs lowers the arch.
*Right*—External rotation of the legs raises the arch.

is not constant even in one individual; it depends on the posture at the moment, and it can be varied at will provided the foot has retained its suppleness (Fig. 14). The posture, just as elsewhere in the body, is determined by the position of the joints which in turn depends on the muscles controlling them. In some positions the arch appears lower than in others, and indeed the outward signs of the arch can almost be abolished in a fully mobile foot.

The degree of mobility varies greatly. Members of those branches of the human race who habitually go unshod or wear only sandals often retain

[illegible] [illegible] [illegible]ility throughout life. Amongst those who wear boots or shoes there [illegible]tendency to lose some movement even during childhood, and in adults restriction is the rule rather than the exception. Such people have not sufficient mobility to enable them to rest the inner borders of their feet on the ground. Since extreme mobility is usual in the new born of all races, there is a prima facie case to attribute the acquired stiffness to the environmental influences of western civilization.

**The Transverse Arch.** This is discussed in connection with pain in the forefoot on page 219.

## Movements of the Foot

The joints between the principle bones of the foot are curved in one or [illegible]re planes and this makes their movements rather complicated. The move-me[illegible]ts can be divided into three groups : an extensive swivelling movement at the subtaloid complex of joints, a moderate range of up and down movement of the inner border of the foot, chiefly the first metatarsal, and a limited amount of up and down movements of the outer border of the foot.

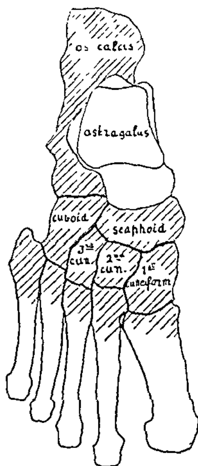



FIG 15 The foot (after Gray's Anatomy) The bones in the shaded area are closely interlocked and move almost as one piece around the axis of th[illegible] [illegible]lus at the subtaloid and tal[illegible] navicular joints

The joints of the entire tarsus, excepting only those in connection with the talus, are spanned by interosseus ligaments, by the tendinous insertions of the tibialis posterior, and by the long and short plantar ligaments, in such a way that only a very limited range of movements is possible (Fig. 15). However, there is very free movement between the talus and the other bones of the foot to which it is joined only by the talo-calcanean interosseus ligament ; this ligament is situated near the axis of rotation of the talus on the calcaneus and permits a considerable range of rotary movement.

The whole foot works together as a unit and moves almost as a solid piece around the talus at the talo-calcanean and talo-navicular joints. These two joints, although they are anatomically distinct, function as one, and they are so shaped that movement in one direction inverts and adducts the foot, and in the other direction everts and abducts it. The former movement raises the inner border [illegible] the foot from the ground (Fig. 16b) ; if the [illegible]rst metatarsal is then lowered without [illegible]llowing the rest of the foot to evert, the height of the arch is increased (F[illegible] 16c).

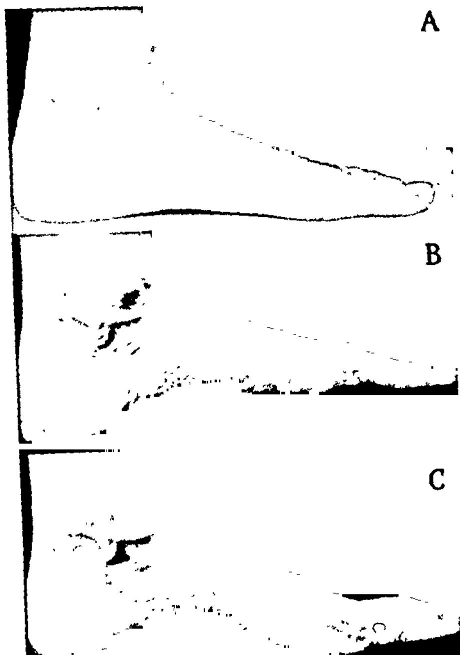



FIG. 16

A. Pes valgus
B. The foot is inverted and adducted at the subtaloid and talo-navicular joints
C. The first metatarsal is depressed and the arch is restored.



Fig 17 Postural pes valgus of moderate severity showing correction obtained by external rotation of the legs at the hips

Similarly the arch is "lowered" into a valgus or "flat-footed" position by everting the foot and raising the first metatarsal.

Identical changes in the posture of the feet are produced by keeping the feet still and rotating the legs because the talus is fixed in the mortice of the ankle and moves with the leg. When the feet are kept still and the legs are rotated to make the patellæ face inwards, the arches are lowered; when the patellæ face outwards, the arches are raised (Fig. 17).

The mid-tarsal joints (i.e. the talo-navicular and calcaneo-cuboid joints) are sometimes stated to be the joints at which inversion and eversion chiefly takes place, but this is not so. These two joints do not form a functional unit and comparatively little movement of the forefoot is possible when subtaloid movement is prevented.

## Muscular Control

The tibialis posterior is inserted into the navicular and has expansions to every other bone in the foot except the talus and the first and fifth metatarsals. When it contracts it approximates the navicular to the internal malleolus, and the whole foot moves with it swivelling round the talus into a position of inversion and adduction (Fig. 16b).

The peroneus longus is inserted into the under-surface of the base of the first metatarsal and the first cuneiform. It is primarily an evertor and abductor of the foot, but when evertion is prevented by the synergic action of the invertors, its continued pull is applied to the bones into which it is inserted and the first metatarsal is depressed (Fig. 15e). The balance of the body, as when standing on one foot, is maintained largely by small variations in tension of the invertors and evertors.

The tibialis anterior is inserted into the base of the first metatarsal and the first cuneiform and its action is rather complicated. Its chief function is to dorsiflex the ankle, but it assists with inversion of the foot and it also elevates the first metatarsal. It is the first muscle to contract when the foot is about to leave the ground thus initiating the small movement of dorsiflexion at the ankle that is necessary, when walking, to enable the toes to clear the ground as the leg swings forward.

The effect of gravity is such that the foot tends to rotate into the everted, abducted position and reduce the visible longitudinal arch. The invertors are comparatively small muscles and they could not alone maintain the inverted position of the foot against the stress of the whole body weight. It has already been pointed out that the shape of the joints is so arranged that external rotation of the leg has the effect of inverting the foot provided the foot is prevented from moving with the leg by pressure against the ground. External rotation of the leg is carried out by the glutei and therefore the powerful gluteal muscles must be included as invertors and adductors of the foot. The action of the talus is not unlike that by which a cam expands the shoes in the brake-drum of a motor-car and it enables the glutei to work at a great mechanical advantage.

[illegible] important movements of the foot are carried out as follows :—

inversion and adduction—tibialis posterior, flexor digitorum longus, *flexor hallicus longus, and the glutei.*

eversion and abduction—peroneus longus and peroneus brevis.

elevation of first metatarsal—tibialis anterior.

depression of first metatarsal—peroneus longus.

Gait. The way in which the foot is used when walking has been studied and accurately analysed by slow-motion cinematography, and by methods of electrical recording using electrodes fastened to different parts of the shoes. The foot touches the ground first at the heel somewhat to the outer side, then at the outer side of the forefoot, and finally at the inner side of the [illegible]. The weight is carried only momentarily on the outer side and [illegible] quickly across the ball of the foot to the inner side; during the [illegible] propulsion it is principally on the ball of the big toe. Movement [illegible] walking takes place chiefly at the ankle joint and the metatarso-[illegible] joints, but there is a little "give" in all the joints of the tarsus [illegible] controlled by the long muscles and the intrinsic muscles. "Spring" [illegible] produced during propulsion by the triceps suræ and flexors of the toes.

## Pes Valgus

The expression "flat foot" is in popular use to describe a number of disorders ranging from simple postural defects to peroneo-extensor spasm and it is expressly avoided here because of these misleading associations. The term "pes valgus," although not strictly accurate, is used instead in the hope that it will lead to clearer thinking.

A valgus posture of the feet may be adopted for many reasons ; it is in fact no more than a symptom which is common to a variety of disorders, just as stomach-ache is a symptom and not a disease in itself. The commonest type of pes valgus is a postural defect of similar ætiology to other postural defects and usually occurring in association with them. There are, however, several minor structural abnormalities which cause the feet to assume a valgus position and it is important to recognize them when they occur. Valgus feet are essentially painless although they are subject to the same causes of pain as are feet of any other shape.

The following varieties of valgus feet may occur separately or in combination :—

1. *Infantile type.*
2. *Part of a general postural defect.*
3. *Associated with genu valgum* (p. 27).
4. *Compensatory to*
    a. Short tendo-Achillis.
    b. Internal torsion of the tibiæ.
    c. Obliquity of ankle joints.
5. *Muscular weakness*
6. *Paralysis.*
7. *Peroneo-extensor spasm* (spasmodic flat foot) (p. 214).

**Infantile Type.** Many infants, particularly asthenic children with long, thin feet, are noticed to have valgus feet as soon as they begin to stand. The reason is probably to be found in the position of the fœtus in utero which may be such as to cause the feet to develop in a valgus position. The condition may be regarded as a very mild talipes calcaneo-valgus with the valgus element predominating (p. 272). The feet have full mobility and there is not usually an associated postural defect.

TREATMENT. A few children rapidly acquire a better posture, a large number show little change until seven to ten years of age when they improve spontaneously, and in the remainder the defect persists into adult life. Active treatment is of little value during the first few years of life but the child should be kept under observation to make certain that the feet remain supple. The heels of the shoes may be wedged if desired. At about six years of age the child is old enough to co-operate in remedial treatment as described for general postural defects.

**General Postural Defect.** Pes valgus is nearly always due to faulty posture and has the same causes as other postural defects, but this will only be appreciated if every patient complaining of "flat feet" is examined completely undressed. The onset is usually during childhood or early adolescence and the posture of the feet is often the first defect to be noticed by the parents. There is a general slump of the extensor muscles which permits the pelvis to rotate forwards increasing its inclination, and the legs to rotate inwards thus twisting the feet into a valgus position (Fig. 17). The nature of the defect can be demonstrated at once by getting the patient to use the glutei to tilt back the pelvis and externally rotate the legs whilst keeping the feet still.

TREATMENT is as for general postural defects (p. 33). *Arch-supports* are of little value in correcting the posture of the feet; their use is a relic of the old idea that the arch is a structure capable of being propped up and it ignores the rotational element. The question of wedging the shoes is contentious. A valgus wedge (i.e. one which corrects a valgus deformity and has the base facing inwards) fixed to the heel of the shoe rotates the foot inwards at the subtaloid joint and gives some correction. If the sole is wedged also, it prevents the inner border of the foot being depressed thus leaving the foot in the same relative position but standing on a sloping surface; wedges should, therefore, be fixed to the heel only. The base of the wedge may be $\frac{1}{8}$ inch thick in infants and $\frac{1}{4}$ inch in older children and adults; thicker wedges are not readily tolerated. They can be fixed as patches outside low heels, but when the heels are higher they should be placed between the welt and the heel to keep the latter vertical (Fig. 18). Although wedged heels are theoretically useful, it is doubtful if they have much effect in practice because [illegible] wear and because they can only help when standing on a [illegible]

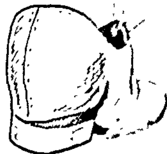


Fig. 18. [illegible]

... are troublesome to keep in repair, and there is a tendency for par... to stop their children running about in bare feet, a much more useful ... because of the wedges." On the whole, wedges are more trouble than they are worth and they serve mainly to let the surgeon think he is ... active treatment without going to the trouble of organizing proper ... methods.

... possible to correct valgus feet by wearing boots or shoes of ... design. The shape of the shoes should correspond to the shape of ... and unless the axis of the feet and the shoes correspond, there ... pressure on one side of the feet. Some shoes, they are often ...gical" or "orthopædic" shoes, are designed with forefoot inclined ...ative to the heel and the axis passes to the outer side of the ... shown in Fig. 19b. The axis of the "normal" foot passes ... the second toe (Fig. 19a), whilst in a valgus foot its falls to the ... side of the second toe. Valgus feet are distorted by shoes of this shape ... pressure on the little toes and outer side of the fifth metatarsal

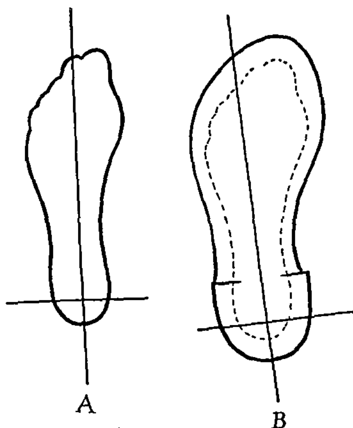



FIG 19 The axis of the shoe B is on the outer side of the second toe and therefore the shoe does not fit the foot A

**Short Tendo-Achillis.** This term is used to describe a condition in which dorsiflexion at the ankle is restricted, although it cannot be said whether it is the ...don or the muscle that is short, or both. A *minor* degree of limitation of dorsiflexion is very common in adults, more so in

women than in men, and it is a frequent cause of valgus feet. The defect appears to be due to failure of the calf muscles to adjust in length during growth, and it may sometimes be attributable to wearing shoes with high heels too early in life.

Dorsiflexion at the ankle is measured with the patient sitting (Fig. 20). The leg is raised to straighten the knee and supported with one hand under the heel; the toes are held with the other hand and the foot is placed in the position it should assume when standing, neither inverted nor everted. It is then dorsiflexed at the ankle with a moderate amount of pressure, care being taken to ensure that it is not forced into valgus as then it appears to dorsiflex more.

The foot normally dorsiflexes to about 20° above a right angle and this range of movement is desirable when walking barefooted. If dorsiflexion to a right angle is impossible, the heel is unable to touch the ground when standing bare-footed unless the forefoot is raised by everting it into the valgus position. When wearing shoes the heels compensate for limitation of dorsiflexion and the feet are not valgus. Minor degrees of limitation do not as a rule cause symptoms although there may be pain after playing games in low-heeled shoes.

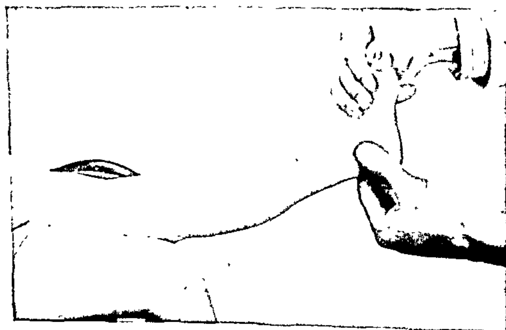


FIG 20 Estimating the range of dorsiflexion at the ankle joint.

TREATMENT. The ordinary postural methods are useless. Young people may be improved by wearing heel-less shoes, by ballet dancing or by physical exercises, but older people should usually be advised to accept the defect and wear heels of a suitable height. Lengthening the tendo-Achillis by operation is very occasionally necessary in children.

Major degrees of shortening of the calf muscles occurring in connection with congenital talipes, and in disorders such as anterior poliomyelitis and spastic paralysis, are discussed in other chapters.

**Torsion of the Tibiæ.** The malleoli in a normal person are not set in the coronal plane but the external malleolus is posterior to the internal. The angle between the plane of the malleoli and the coronal plane is between 20° and 30°; it can be estimated roughly when the patient is seated and the legs are held with the knees straight and the patellæ facing exactly upwards. Variation in tibial torsion causing the feet to point in a different direction from the knees is quite common and should be sought as routine.

The common abnormality is an increase in internal torsion; the external malleoli are advanced in relation to the internal and lie in the coronal plane or in front of it. The feet therefore point inwards (Fig. 21) and since this pigeon-toed position is awkward, the patient unconsciously everts the feet into a valgus position to make them parallel. Sometimes there is an associated general postural defect in which the hips are internally rotated; this causes the valgus posture of the feet to be more extreme and may mask the torsion deformity unless it is looked for. External torsion deformities have the opposite effect and are an occasional cause of pes cavus.

TREATMENT. Torsion deformities in infants usually decrease during growth but they do not always disappear entirely. A slight residual defect causes little inconvenience and should be accepted. When there is a considerable defect at about six years of age, and this is rare, it may be corrected by rotation osteotomy of the tibiæ; the operation is simple, and gives satisfactory results in properly selected patients.

It is possible to correct the valgus posture of the feet by externally rotating the legs at the hips to make the patellæ face outwards. This position is difficult to maintain and is uncomfortable because the feet cross when the knees are bent during walking and running, and therefore it is not advised.



FIG. 21 Internal torsion deformity of the tibiæ

**Obliquity of the Tibial epiphyses.** The lower articular surfaces of the tibiæ sometimes fail to develop evenly and slope a little inwards instead of being parallel with the ground. The soles of the feet then face slightly towards each other, but when bearing weight they are restored to the horizontal by evertion into the valgus position. The deformity may be due to mild rickets but sometimes no cause can be found.

The condition can be detected clinically by the position of the feet when they are passively held in their natural position in relation to the tibiæ. It is confirmed by X-rays taken of both legs whilst the patellæ are facing exactly forwards (Fig. 22). The general impression given by the defect



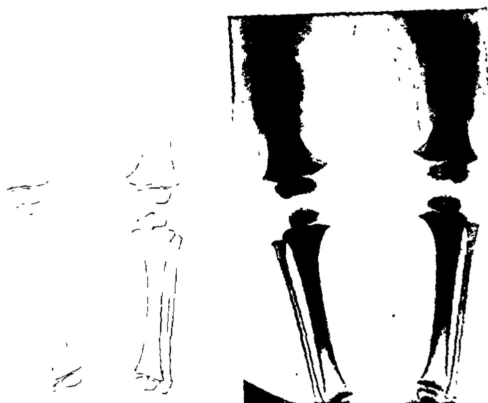


FIG 22 *Above*—X-ray of a child aged 20 months with straight legs
*Below*—Obliquity of the lower tibial epiphyses causing pes valgus

incurving of the tibiæ (p. 32), but whilst it is true that severe incurving of the tibiæ causes obliquity of the ankles, radiological examination shows that the reverse does not hold and obliquity is often present without incurving.

TREATMENT. There is often spontaneous improvement during growth and no treatment is possible except on the rare occasion when the deformity is severe enough to warrant wedge osteotomy of the tibiæ.

**Muscular Weakness.** Habitual pes valgus is not ordinarily caused by muscular weakness. Temporary valgus may, however, occur as the result of fatigue, for example, in a young adult first starting work which involves much standing, such as shop assistant. The whole extensor mechanism then tires, the body sags and the feet rotate into valgus. When the feet are supple this causes little more trouble than tiredness and aching, but if the feet are stiff, it may produce chronic foot strain (p. 212).

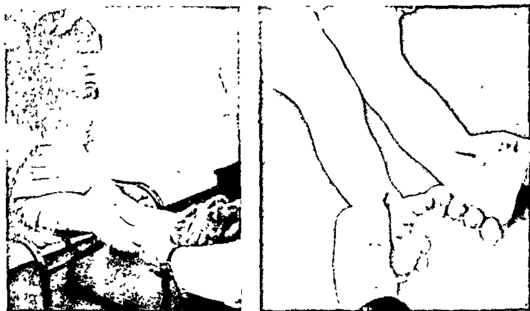


FIG. 23 Measuring the amount of knock-knee The knees must be kept straight and the patellæ facing exactly upwards

**Paralysis.** When the invertor muscles are paralysed, particularly the tibialis posterior, the foot assumes a position of extreme valgus. The commonest cause is anterior poliomyelitis. Residual weakness or paralysis of only one group of muscles is not uncommon after this infection and the possibility should be remembered even when the acute attack passed unnoticed (p. 153).

**Peroneo-extensor Spasm.** (Spasmodic flat foot.) This is not a postural defect but an entirely different condition in which the valgus position of the foot is merely incidental. It is readily recognized by the obvious spasm of the peroneal muscles and the long extensors of the toes which prevents passive correction of the deformity, and it should not be overlooked because immediate treatment is necessary. It is further discussed on page 214.

## GENU VALGUM

### (*Synonym*) Knock-Knee

Knock-knee is a disorder which usually starts during childhood although it may persist throughout life. There are two common types of knock-knee, an "idiopathic" type in which there is a temporary defect in growth of the lower end of the femur, and a type due to disease of bone, usually rickets.

The amount of knock-knee is measured by the distance between the internal malleoli as shown in Fig. 23. Care must be taken to make sure that the knees are straight and the patellæ face exactly upwards; the legs are brought together with moderate pressure which is applied firmly enough to compress excessive subcutaneous fat. The amount of pressure used by one surgeon can always be about the same and his estimations of knock-knee are fairly constant, but different surgeons may obtain different measurements for the same patient. Excessive subcutaneous fat exaggerates the clinical appearance of knock-knee.

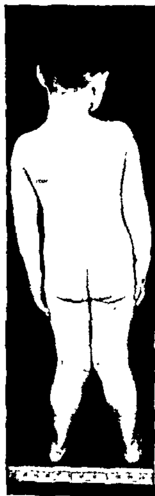


FIG 24 "Idiopathic" knock-knee There was no evidence of rickets.

### "Idiopathic" Type

The usual type of knock-knee in children in Great Britain, where florid rickets is now uncommon, is due to unequal growth of the femoral condyles (Fig. 24). The internal condyles in affected children grow more rapidly than the external, and the line of the knee joint, instead of being horizontal, slopes slightly outwards. In a large majority growth of the external *condyle eventually catches up with the internal and* the defect rights itself spontaneously. Many children, perhaps as many as a third of all the children in the country, are knock-kneed at some stage of development, but adults with even a trivial amount of deformity do not exceed two per cent of the population.

Laxity of the internal lateral ligaments is often present in knock-knee because of the additional strain that falls on the inner side of the joints. *This* allows the joints to "open up" whilst standing relaxed thus increasing the amount of deformity, but the laxity is controlled by muscular action when *walking* or running.

Pes valgus is frequently associated with the more severe degrees of knock-knee, especially in heavy children. There is often a poor general posture with an internal rotational defect of the legs, and pes valgus occurs partly in compensation for this (p. 21), and partly because of *increased*

pressure on the inner borders of the feet. The posture of the feet usually recovers spontaneously as the knees become straight, but remedial treatment is required if the internal rotation defect persists.

Knock-knee often begins to develop a few months after the child starts to walk. A distance of one inch between the malleoli is common by two years of age, and sometimes there is two inches or more. The deformity may then remain stationary for a while before regressing, or it may progress until there is three inches at three to four years of age. The legs are usually straight again by the time the child is six years old.

The prognosis is excellent provided the amount of knock-knee does not exceed about two and a half inches. If it is three inches at three years, the outcome is doubtful although spontaneous correction is still the rule; the child should be examined at three monthly intervals and continued progress is an indication for active treatment. Excessive weight adversely affects the prognosis because the pressure on the internal condyles is increased.

**Treatment.** "Idiopathic" genu valgum almost always recovers spontaneously and treatment is of doubtful value to most patients. They should avoid standing as much as possible and they should not be made to stand or walk with the feet together, indeed it is an advantage to walk with them apart. Knock-kneed children are clumsy in their movements because their knees get in the way; they have less difficulty if they keep the feet apart, and this also reduces the soreness suffered by fat children whose thighs rub together. Gymnasium and drill teachers should be instructed accordingly.

A few mothers insist on "something being done" but most are satisfied with a detailed explanation and are relieved to find that they have nothing to do—the neighbours often worry more than the mother. The only conservative measure available is to wedge the inner sides of the soles and heels of the shoes. The intention is to relieve the strain on the inner sides of the knees but there is no evidence that recovery is thereby accelerated (p. 21). Massage and remedial exercises are without effect on the deformity.

More active treatment is occasionally necessary but the indications are difficult to define exactly because the percentage of patients likely to recover spontaneously from different amounts of deformity is not known. Treatment is certainly desirable, particularly in fat children, when the deformity has reached three inches by the age of three years and continues to progress during the next year.

The choice of active treatment is between splints and operation. Splints have to be worn for a very long time, often a couple of years. Day splints are cumbersome and interfere with activity to a crippling extent placing the child in grave danger of acquiring cripple's mentality; night splints are open to less objection, but are less effective. On the other hand osteotomy is a safe procedure with a fairly short convalescence which enables all treatment to be finished in about three months. It is most undesirable, if there is any alternative, to inflict a long period of crippledom

on a child, and operation is greatly to be preferred on the rare occasions when active treatment is necessary.

SPLINTS. The object of splinting is to apply constant pressure to the leg in such a manner as to increase the stress on the internal condyle of the femur and reduce it on the external condyle, and it must be continued for long enough to allow the condyles to grow the proper size. Three points of pressure are required—the great trochanter and the external malleolus on the outer side, and the internal epicondyle on the inner side. The corrective force operates only when the knee is straight because when it is bent the leg rotates. Splints consisting of a single bar at the outer side of the leg are therefore useless, and it is necessary to have a second bar behind the leg to keep the knee straight.

Splints for night use are generally made from two long pieces of wood of slightly curved cross-section; the shorter piece is bandaged to the back of the leg and then the longer is applied to the outer side. Day splints consist of a long outside iron with the lower end in a round socket in the heel of the shoe, the upper end is padded to press on the great trochanter, and a short posterior iron is attached to the long iron by two quarter hoops; the leg is fixed in the splint by bandages or straps (Fig. 25).

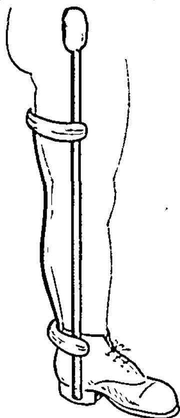


FIG 25 Knock-knee splint. The straps are not shown

OPERATION. *Macewen's Osteotomy.* The modification now frequently practised is to introduce an osteotome on the outer side of the femur about 1½ inches above the epiphysial line and divide the bone three-quarters of the way through; the remaining portion is then fractured leaving the periosteum on the inner side intact. A double plaster-of-Paris spica is then applied, or else traction as for a fracture of the femur.

*Blount's Staples.* Blount has recently introduced a method of temporarily restricting growth of all or part of an epiphysial disc by bridging it with staples driven across it into the bone. The staples are removed when sufficient correction has been obtained, and it appears that subsequent growth is unaffected. Should the operation prove to be as satisfactory as the early work suggests, it will be a valuable method of controlling knock-knee because the child's activities are only interfered with for a few days.

## Rickets

Rickets is the only common disease of bone to cause knock-knee although sometimes it is due to rare affections such as dyschondroplasia. Renal osteodystrophy is an occasional cause and therefore the urine should always be tested for albumen. A generation ago florid rickets was prevalent

in Great Britain, but now it is quite rare and therefore knock-knee due to rickets is seldom seen. Knock-knee should only be attributed to rickets when there is definite radiological evidence of the disease (p. 433).

The deformity is due partly to the soft bones bending where the stress is greatest, that is the lower part of the shaft of the femur, and partly to compression of the external condyles of the femur and tibia which are subjected to greater pressure than the internal condyles. A "back knee" deformity (genu recurvatum) is not uncommonly associated.

The deformity in knock-knee due to rickets is often greater than in the "idiopathic" type, and since the tendency to spontaneous recovery is smaller, active treatment is more often necessary. Treatment follows the lines already described but there need be less hesitation in advising operation, three inches of deformity at three years is a definite indiction.

## GENU VARUM

(*Synonym*) Bow Legs

Tibiae of normal shape are not quite straight but the inner borders are slightly curved, and this is apparent on both clinical and radiological examination (Fig. 22); a straight shin, as may be seen with a malunited fracture, is conspicuous and ugly. *Real* bow legs is due to incurving of the tibiæ, and it is now uncommon in Great Britain because the usual cause is florid rickets. *Apparent* bow legs is, however, common; it may be caused by internal rotation of the legs at the hips, and by obliquity of the lower tibial epiphyses, both of which are further considered below. It is probable that apparent bow legs is also caused by a similar defect to knock-knee, i e. unequal rate of growth of the femoral condyles, because sometimes a child is bow-legged at one period of life and knock-kneed a year or two later. This type of deformity nearly always corrects itself during growth and treatment is unnecessary. Occasionally both deformities are present at the same time, the legs being valgus above the knees and varus below them.

The amount of bow legs is measured in a similar way to knock-knee, the internal malleoli being brought together and the distance between the knees measured (Fig. 23).

### Internal Rotation of the Legs

Internal rotation at the hip joints, which is a common postural defect, is the usual cause of apparent bow legs in older children and adults. The appearance is produced when a rotational defect is accompanied by some hyperextension of the knees (genu recurvatum). The reason is that the legs, when viewed from the side, are slightly curved and the plane of the curve is changed by rotation of the legs (Fig. 26). The appearance is immediately corrected by rotating the legs outwards and the treatment is as for other postural defects.

### Obliquity of the Tibial Epiphyses

Obliquity of the lower epiphyses of the tibiæ has already been mentioned in connection with pes valgus of which it is an occasional cause (p. 24).



FIG. 26. Apparent bow legs and pes valgus caused by internal rotation of the legs at the hips

The radiological appearance suggests that the defect is often due to mild rickets ; it may, however, be present in infants with no evidence of vitamin deficiency and then it appears to be due to a temporary defect in growth similar to that in genu valgum.

The defect can be recognized clinically by the slight inward inclination of the heels and the similar inclination of the forefeet when they are placed in their proper position in relation to the heels. The legs then look as if they were bowed, but there is no gap between the knees when the feet are everted to enable the malleoli to be brought together. X-rays show the nature of the defect and also confirm the absence of bowing of the shafts of the tibiæ (Fig. 22).

The defect usually corrects itself spontaneously during growth. A minor degree sometimes persists but it causes no more inconvenience than slightly valgus feet. Very occasionally the defect is severe enough to require correction by osteotomy of the tibiæ, and on the rare occasions when this is necessary it should be done during early childhood.

## Rickets

Florid rickets, although the commonest disease causing bones to soften and bend, is now seldom seen in Great Britain, but when it does occur, the deformity may be very severe (p. 431). The point at which the tibiæ bend depends to some extent on the age of the child. In infants the curve

is chiefly in the lower third of the tibiæ (Fig. 27), but in older children the whole length of the bone may be involved. A backward curve is often superimposed on the inward bowing when the child is young enough to be carried in the mother's arms with the legs hanging over her forearm. The backward element of the deformity, when present, is an important point in the clinical diagnosis because it only occurs when the bow legs is due to *softening of the bones.* Obliquity of the lower tibial epiphyses is also present in rickets and may be very marked.

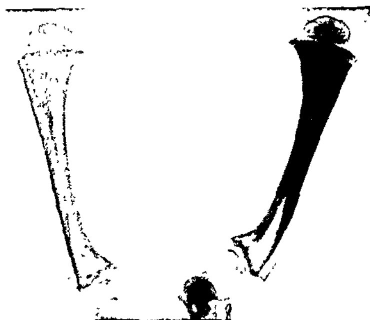


FIG 27 Incurving of the lower ends of the tibiæ and obliquity of the lower epiphyses caused by florid rickets (cf Fig 22)

**Treatment.** Spontaneous recovery does not occur except with a trivial amount of bowing and treatment is desirable when the deformity is at all severe, if only for cosmetic reasons. There is, however, no simple method of correction because splints, which have the same drawbacks as in the treatment of knock-knee, should be avoided when possible.

OSTEOCLASIS. This is indicated when there is an appreciable amount of backward bowing, and when there is a gap between the knees of three inches or more at the age of three years. With intermediate degrees of deformity it may be hard to decide when to advise this procedure, but it is a comparatively minor operation and the results are good. The leg is placed with the apex of the convexity of the curve resting on a wedge; it is held close to the wedge to avoid strain on the epiphyses, and fractured. As a rule there is a complete fracture of the fibula and a *greenstick fracture* of the tibia The legs are afterwards fixed in plaster-of-Paris in the corrected position for six weeks.

WEDGE OSTEOTOMY With very severe deformities in older children it is preferable to remove a wedge of bone from the convexity of the tibial curve.

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leads to a habit that facilitates performance of the movement. This habit is composed of two parts; firstly, assuming the position in which the movement begins and ends, and secondly, making the movement itself. The first teaches the desired posture and a ready return to it at the end of the movement, whilst the second teaches control of posture during movement and in varying conditions of balance. The mere making of movements is not the object of exercises; it is the way they are made that matters and the patient must be watched the whole time to ensure that the correct posture is held throughout.

Exercises are used in the earlier stages of treatment to increase mobility and ensure voluntary control over the movements correcting a defect. Later, they should be designed to teach the maintainance of posture in all conditions of balance and during the ordinary movements of life. It must be remembered that a correction of, say, the pelvic inclination, has to be held whilst walking, and that the poise of the head and shoulders is of importance not only when standing, but also during common-place movements like getting up from a chair. Exercises should therefore include such ordinary movements, and once the new posture has been learnt it should be held whatever movements are made. Walking with the feet and legs corrected does not prevent any great difficulty, but it has to be taught specifically. Shoes with heels of the customary height may usefully be worn part of the time.

Patients when given exercises to do at home tend to concentrate on the easier at the expense of the harder. It is doubtful if any exercises other than just holding the corrected position should be done when alone, except perhaps those for restoring mobility. Exercises of no special value should be avoided; an example is walking round the room on the outer borders of the feet which teaches the use of a wrong posture, and because it is easy to do, it gives the less intelligent patient a false idea of what is required.

Success or failure in treatment depends on the extent to which the co-operation of the patient is obtained. The enthusiasm, understanding and personality of the teacher have full scope in work of this kind. The patient has somehow to be made to *want* to get better. During the remedial class he is taught how to get into the new posture, and how to hold it in a variety of conditions; the habit becomes permanent only if he continues to try after the class is over, and success is impossible if he drops back into the old posture as soon as he is out of the class-room. It is difficult to sustain interest and enthusiasm, even during class, by giving dull, routine exercises, and much ingenuity is required to introduce variety. Music can be used freely, and with suitable patients ball-room dancing is a useful variation. It so happens that the training for classical ballet requires movements that are readily adapted for correcting postural defects. In the absence of other facilities ballet dancing may well be prescribed for musical children, provided extreme external rotation of the feet is avoided and work on the "points" excluded, and it has the added advantage of giving poise and grace as well as correcting posture.

completely but maintains sufficient tone to control the joint concerned. But when a movement is made against resistance, the muscle can relax completely because control is obtained by pressure between the resistance and the contracting muscle. Hence to "stretch" a muscle, its antagonist must be made to contract against resistance, and to continue to work against the resistance after the extreme of movement is reached. For example, if the leg is allowed to hang over the edge of a couch whilst the patient lies supine upon it, the movement is favoured by gravity and the flexors have to contract to control it; but if one leg is extended backwards whilst the patient stands, gravity resists the movement and the flexors are able to relax (Fig. 28).

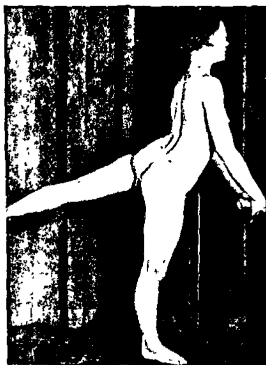


Fig. 28.

**Voluntary Control.** The movements necessary to correct a postural defect are easily learnt when there is adequate mobility, but care must be taken to study the mechanics of the defect and ensure that the proper groups of muscles are used. For example, when the pelvic inclination is increased, the glutei are the right muscles to restore it to normal. The abdominals, which contract synergically with the glutei, help to restore the contour of the abdomen but they do not materially affect the pelvis. The glutei are also used to correct pes valgus by externally rotating the hips.

**New Postural Reflexes.** Reflexes are established only as the result of the habitual use of the new posture—this is the final aim of remedial work. The role of exercises is often misunderstood. An exercise consists in making a specified movement which begins in a particular position and finishes usually in the same position. Frequent repetition

Physical examination requires particular care or an entirely false impression may be obtained. No reliable conclusion can be drawn from one or two isolated observations, and negative findings are as important as positive. The whole patient must be examined, not only the part of the back complained of, or some causal fault may be overlooked. The patient should be entirely undressed, or wear no more than a "triangle," because posture and movement cannot be judged with half the body concealed—even a pair of knickers covers the sacroiliac and hip joints. Mistakes in diagnosis are less likely if a full routine is always followed.

SCHEME OF EXAMINATION.

| | |
|---|---|
| *Standing* | Body build and musculature. |
| | General posture. |
| | Deformities. |
| | Site of pain and direction of radiation. |
| | Active movements—flexion |
| | extension. |
| | side bending. |
| | rotation. |
| *Sitting.* | Active movements—as above. |
| *Lying supine.* | Posture. |
| | Hips—all movements. |
| | Spine—passive movements—flexion. |
| | rotation. |
| | Lasègue's test. |
| | Abdominal palpation. |
| *Lying on side.* | Rotation. |
| *Lying prone.* | Posture. |
| | Tenderness. |
| | Passive movements—hips—*extension.* |
| | spine—extension. |
| | Ely's test. |
| *C.N.S.* | Routine examination. |
| *Rectum.* | Digital examination. |

The patient is first examined standing. He is asked to point to the site of pain and also the direction in which it radiates. The general body build and posture are noted and also temporary alterations in posture, such as obliteration of the lumbar curve or a list to one side.

Active movements are examined both when standing and sitting. Flexion, extension, side-bending and rotation are carried out in turn and restriction of movement and pain are noted. The movements of the back should have a smooth rhythm in which each vertebra takes a share abnormality is specially noticeable during flexion when a section consisting of two or three vertebræ may be fixed by spasm and fail to take part in the movement. Ability to touch the ground with the fingers is no indication of a normal spine because this achievement depends to some extent on the

CHAPTER II

# BACK PAIN

Back pain might almost be described as a universal symptom for it occurs with every variety of ailment from renal calculus to intervertebral disc protrusion, from heart failure to osteoarthritis. The severity of pain in the back is even harder to assess than pain elsewhere. There is no method of gauging it and reliance has to be placed on objective signs such as the manner in which it is recounted, the facial expression, and the extent of interference with the habitual mode of life. Almost everyone has backache at some time or other, and some have it more or less continually, but only a proportion of sufferers complain of it. Neither the intensity of the pain, unless it be of extreme degree, nor its duration, are in constant proportion to their objective effect and it is easy to form a wrong impression. The frequency with which symptoms in the back and a neurotic personality co-incide is notorious, but the difficulty of cure by psychological methods is equally well known. Back pain is a psychosomatic problem, and whether the symptoms are slight or severe, whether the diagnosis is "fibrositis" or sciatica, it is safe to say that sooner or later there will be psychological implications. But whatever the nature of the pain, be it predominantly organic or psychogenic, it is equally serious to the patient and just as worthy of cure.

Pain in the back may be caused by disease or disorder in function of any structure in the back, that is to say by the vertebræ and intervertebral discs, by the joints and ligaments, and by the muscles and nerves controlling them. The precise ætiology and pathology are often unknown, or are a matter for speculation, and it is difficult to reduce discussion to order. The classification adopted here is a clinical one and back pain is divided into four main groups—acute and chronic back pain, coccydynia, and back pain associated with sciatica. Acute back pain includes all cases of short duration, and chronic back pain those of longer duration whether or no there have been remissions.

### Examination

A full histor[illegible] is essential. The story of the pain should commence with the first [illegible]ision it was felt and continue through remissions and exacerbations to the current attack. Details of other illnesses and the obstetric history may be important, and enquiry into the family history and environmental conditions help in assessing the patient's personality.

flat on the couch, flexing the other leg places a torsional strain on the corresponding sacroiliac joint.

Rotation is also carried out lying on the side. When the spine is extended, the lumbar and dorsal joints are moved as well as the sacroiliac joints, but movement can be restricted to the sacroiliacs by drawing up the lower leg to flex the lumbar spine (*Fig.* 38, p. 30).

Extension is examined with the patient prone. Lifting one leg alone causes a forward torsion strain on the sacroiliac joint. Lifting both legs





FIG. 30. Examining the spine in extension.

together extends the lumbar and dorsal spine without straining the sacroiliacs (Fig. 30).

Localized points of maximum tenderness are elicited with the patient prone and should be distinguished from the widespread tenderness of muscles in spasm (Fig. 40, p. 52). There is sometimes tenderness at a point remote from the region in which pain is felt, and pressure on such a point causes referred pain. Points of tenderness may only be found after diligent search, if necessary going over the muscles inch by inch.

There are two tests of special value in low back pain but they are only of significance when interpreted in conjunction with the other findings ;

*Laségue's sign* is elicited with the patient supine, one leg being raised with the knee straight, whilst the other remains flat on the couch to restrict

relative length of the hamstrings, and some people can touch the ground when the whole lumbar spine is rigid. Returning to the upright from flexion or extension is often more painful than the original movement. There may be a difference in the range of movements when standing and sitting; for example, the hamstrings limit forward rotation of the pelvis *at the hips when standing, but not when sitting with the knees bent, and* therefore there is greater strain on the sacroiliac and lumbosacral joints when standing.



FIG 29. Examining the spine in flexion

The way the patient gets on to the examination couch, the posture he adopts on it, and how he moves from one position to another give valuable information about the severity of the pain. Conscious or unconscious exaggeration of symptoms may be betrayed by the way he lies. Thus a patient who appears completely unable to hollow the back when sitting may lie on the couch with the hips and knees bent and the lumbar curve exaggerated Movements of the hips must always be examined because limitation at the hips affects the posture of the spine.

The methods of examining flexion of the lumbar spine, and rotation in flexion, are illustrated in Fig. 29. Both movements are confined to the lumbar and dorsal spine provided the legs are moved together. If, however, movement of the pelvis and lumbar spine is restricted by holding one leg

joint, but no experimental or pathological evidence is offered in support. The only cause known with certainty is protrusion of an intervertebral disc, but this is responsible in only a proportion of patients. The symptoms with a disc protrusion sometimes present themselves abruptly, and, in the absence of pain radiating along the leg or arm, the condition may at first be indistinguishable from less serious causes of pain.

Young adults and those of early middle-age are specially liable to

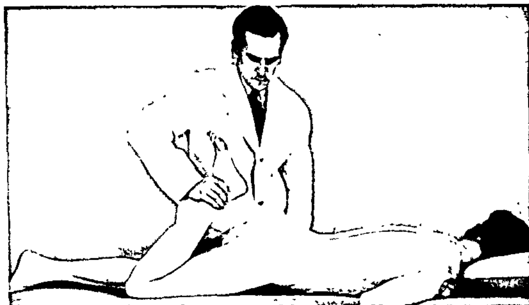


FIG 32 Ely's sign.

disorders of this group although they are not uncommon at any age. The onset is frequently associated with minor trauma, such as a jerk when getting on to a moving bus. Sometimes there is an abrupt onset during a movement like swinging a golf club, but sometimes pain comes on gradually during the day without any apparent cause, or is first noticed on waking in the morning. Symptoms can be of any degree of severity; during a severe attack the patient is completely unable to move and cannot even change position in bed, but in a mild attack he may complain only of stiffness and pain on making certain movements.

Examination shows spasm of the erector spinæ of one or both sides which limits active movements of a portion of the spine. Passive movements are painful, but with extreme gentleness it may be possible to "coax" quite a good range. Pain at first is localized, but after a time it radiates widely. The point of greatest tenderness corresponds to that of greatest pain, but there is some tenderness over all the muscles in spasm. Radiological examination is negative, and although stereoscopic films are sometimes said to show a small amount of rotation of one vertebra on another, a similar appearance is often seen in the absence of symptoms.

**Treatment.** Most patients recover spontaneously in the course of time but manipulation sometimes brings rapid relief and saves much pain. Disc lesions appear to respond to manipulation just as well as the others,

movement of the pelvis. Normally the leg can be lifted 90° or more, the exact distance depending on the hamstrings. Limitation of movement and pain are usually present in low back pain and sciatica, but not necessarily to an extent proportionate to the severity of the symptoms. When the leg is raised until pain is just felt, dorsiflexion of the foot increases the pull on the sciatic nerve without altering the tension of the hamstrings, and this increases sciatic pain but not pain from other causes (Fig. 31).



FIG 31 Lasègue's sign

*Ely's sign* is demonstrated in the prone position by flexing one knee *until the heel touches the buttock. This stretches the anterior muscles of* the thigh and, in a normal person, the pelvis is rotated forwards and the lumbar curve increased, but when the sign is positive, the pelvis rises from the couch (Fig. 32). A positive sign is present when there is restriction of movement of the lumbar spine from any cause, when there is sacroiliac pain, and when there is marked contraction of the anterior thigh muscles.

**Cervical Region.** The movements of the neck are most easily examined when the patient is lying prone with his head projecting beyond the couch and supported on the surgeon's hands. The range of passive movements in this position is greater than the active range when sitting or standing ; there is at least 90° of rotation in each direction (Fig. 33, p. 43), and side bending can be continued until the ear touches the shoulder.

## ACUTE BACK PAIN

Pain in the back of rapid onset and not associated with known organic disease is a familiar and disabling complaint. Included under this heading are several conditions with names descriptive only of the part of the body concerned, such as acute stiff neck and acute lumbago. The ætiology in many instances is quite unknown. Suggested explanations include nipping of a fringe of synovial membrane, and subluxation of an intervertebral

attack all the muscles of both sides are involved, but in a mild one the spasm may be limited to a small area. There is tenderness over one or two of the intervertebral joints and to a lesser extent over the whole of the muscles in spasm. Pain may radiate over any area within the distribution of the cervical roots; it is often referred to the back of the head when the upper cervical joints are affected, and to the shoulders when the lower joints are involved. Active and passive movements of the neck are limited in some directions; rotation is usually greatly restricted, and causes the patient to turn the whole trunk when looking to one side, instead of the neck alone.

Disease of the vertebræ is excluded by radiography. In young people the possibility of atlanto-axial dislocation must be considered because it sometimes occurs without other symptoms after an attack of tonsillitis or one of the exanthemata. With lesions of the cervical intervertebral discs, the foraminal compression test is usually positive (p. 280), and pain is often referred to the shoulder and arm.

**Treatment.** The majority of patients recover quickly enough for manipulation to be unnecessary, but it is a helpful procedure when the pain is severe or rapid recovery is important. The neck is manipulated with the patient supine on a couch and the head and neck projecting over the end. Since the head is supported only by the surgeon's hands, care must be taken not to remove the support for an instant, even when the position of the hands is being changed, because the patient will not relax unless he feels absolutely secure. The range of passive movements of the neck in this position is greater than the active range when standing up. Rotation is possible through more than 90° in each direction and side-bending can be continued until the ear touches the shoulder.



FIG 33 Manipulation of the cervical spine —rotation.

The manipulative movements usually carried out are a continuation of rotation and side-bending beyond the normal active range. For rotation to the right, the head is supported on the left hand with the occipital protruberance lying in the cleft between the thumb and index finger and the side of the face resting on the fingers. The fingers of the right hand are placed under the chin and the head is rotated gently to the right whilst slight traction is made. When the extreme of movement is reached, but not before, a very small additional twist is made sharply (Fig. 33). The position of the hands is reversed for rotation to the left.

Side-bending cannot be carried to an extreme because the shoulder is in the way, and therefore the neck is bent round a fulcrum. The head is

but only during the first attack and less often in subsequent ones. The more abrupt the onset, the greater the chance of relief by manipulation. The pain does not disappear immediately after manipulation, although the patient is often aware of a difference in its character, and as a rule there is gradual improvement until after a day or two nothing remains but a little soreness in the muscles. Radiological examination to exclude disease of the vertebræ is an essential pre-requisite to manipulation.

Manipulation is a simple business which should be part of the therapeutic armamentarium of every doctor and physiotherapist, and it will be described in detail because many are not familiar with it. The technique is subject to considerable individual variation but the general principle is always the same and is quickly learned. Manipulation for acute back pain is usually possible without anæsthesia, but an anæsthetic is desirable when there is severe pain and spasm—the need for anæsthesia varies inversely with the skill of the surgeon. No greater force is necessary when an anæsthetic is used, but complete relaxation is essential and nitrous oxide alone is seldom satisfactory. Mild pain, particularly in the dorsal spine, responds at least as well without an anæsthetic as with it.

The object of manipulation is to impart a movement which is not under voluntary control. This movement, in many joints, causes a palpable and audible click, but it must be emphasized that a click is obtained from normal joints just as readily as from painful ones and it is of no significance except as an indication that the joint has been moved. A click can only be obtained a second time from the same joint after a short lapse of time, and the manipulation can be equally effective when no click is heard. The force used is small, the weight of the patient's limb alone sometimes being sufficient to move the joint; to force a movement against resisting muscles is not only painful, but harmful, and therefore the muscles *must* be relaxed.

After relaxation has been obtained, either with or without the aid of anæsthesia, the joint is moved to the extreme of its normal range and then a rather sharp movement of small excursion carries it slightly further. The manipulative movement is made gently but firmly, and it must not be started before the joint is at the extreme of the normal range. If it is begun earlier the patient has time to contract his muscles and check it, and this not only prevents the manipulative movement being made, but also is painful. Manipulation cannot always be localized to one joint and often several joints, including the affected one, are moved.

## Cervical Spine

Acute stiff neck is of common occurrence. The onset is usually rapid, and sometimes abrupt, but not infrequently it is first noticed on waking in the morning. The patient is first aware that the neck is a little stiff and painful and often puts it down to "sitting in a draught." The symptoms get worse during the next few hours and may become bad enough to cause considerable inconvenience; occasionally the pain is really severe and it is difficult even to turn over in bed.

Examination shows spasm of the muscles of the neck; in a severe

right thumb and a downward thrust of the chest in the direction of the patient's arms. It is important to keep the spine flexed throughout.

There is a method of manipulating the intervertebral joints with the patient sitting which nearly always succeeds when relaxation cannot be obtained in other ways. The patient is held as shown in Fig. 35, the surgeon's hands being locked behind the patient's neck as in a "double Nelson," he is lifted an inch from the stool and then told to sit down ; when he tries to do so, his muscles automatically relax, and then a sharp movement of small excursion is made forwards with the knee and backwards with the hands. If the patient is too heavy to lift alone, help can be given by two assistants each supporting one of his elbows.





FIG 35 Two methods of manipulating the dorsal spine

## Lumbar and Sacroiliac Joints

*Acute "lumbago"* is a complaint of varying ætiology in which there is spasm of the lumbar muscles. A classical example is when the patient is engaged in an occupation such as golf and is smitten by a sudden pain in the loin ; he is unable to move and is carried home where he remains in bed in great pain which only subsides after some days. The onset is often less dramatic and the pain may be noticed first on waking in the morning, or it may come on during the day without known cause and increase rapidly in intensity. The condition appears to be due sometimes to disorder of the lumbar or lumbosacral joints, and sometimes to protrusion of an intervertebral disc. Diagnosis of an intervertebral disc lesion may be impossible at an early stage, but careful and gentle manipulation is not contra-indicated and it often relieves the symptoms.

Examination shows spasm of the lumbar muscles, usually on one side more than the other ; occasionally spasm is extreme and involves even the

supported on the left hand as before and carried well to the left; the radial border of the forefinger of the right hand is pressed firmly against the transverse processes of the vertebræ at the affected level. The right hand is held rigid with the thumb extended so as not to press on the trachea. The neck is then bent to the right whilst the right hand is pressed to the left, and when the extreme of movement is reached, a small thrust is made with both hands simultaneously (Fig. 34).



Fig 34 Manipulation of the cervical spine—lateral bending

## Dorsal Spine

Pain of sudden onset is less frequent in the dorsal region than in the more mobile parts of the spine. It is similar to that in the cervical spine and sometimes starts abruptly from just coughing, sneezing or stretching the arms above the head. The pain may radiate along the intercostal nerves, and sometimes along the first thoracic nerve to the ulnar border of the arm and hand. Examination shows spasm of the erector spinæ, tenderness over the affected joints, and limitation of movement, particularly rotation. Diagnosis has to be made from disease of the vertebræ or ribs. Prolapse of an intervertebral disc appears to be uncommon in the dorsal region but there is some evidence that a dorsal prolapse may cause pain which simulates visceral disease.

**Treatment.** An anæsthetic is seldom required for manipulation of this region. The costo-vertebral and the upper intervertebral joints are manipulated with least discomfort to the patient when he is supine on a couch (Fig. 35). His hands are placed with fingers interlaced behind his neck and his elbows brought together in front of his face; his forearms are held with the surgeon's left forearm and hand, and his elbows pressed against the surgeon's chest. The upper part of his spine is then passively flexed and the ball of the surgeon's right thumb placed under the painful joint. The patient is then told to let his shoulders drop back on to the couch, and the moment his muscles are felt to relax, but before he actually moves, the manipulative movement is made by an upward thrust of the

others search only for toxins and hidden peculiarities of metabolism, and yet others think only of intervertebral disc lesions. But the patient should be looked at as a whole so that all these views, which may be but different facets of one problem, can be seen in proper proportion. There is no panacea for backache. Successful treatment is based on the painstaking consideration of the individual patient and involves not only the temporary relief of pain, but also removal of the underlying cause to prevent recurrence.

It is an advantage to have in mind a classification of the more usual causes of chronic back pain, even though it is not always possible to be precise as to the ætiology in a particular patient. The classification adopted here is a compromise between the demands of ætiological accuracy and the requirements of therapy. The treatment of all types is discussed together on page 57.

*Strain on Ligaments* muscular fatigue.
postural defects.
congenital deformities.
acquired deformities.
acute strain.

*Sacroiliac inflammation.*
*Myofascial pain.*
*Osteoarthritis.*
*Trauma.*
*Root pressure.*
*Intervertebral disc lesions.*

## Strain on Ligaments

Ligaments, as explained on page 1, are liable to hurt when subjected to continuous strain. They are normally protected by the muscles which maintain the posture of the joints at an intermediate point in their range of movement, but if there is absolute or relative muscular insufficiency, excessive strain falls on the ligaments and joint capsules. This may occur during periods of chronic ill-health, particularly if there is already a postural or structural defect causing the muscles to work at a mechanical disadvantage. People with a minor defect often remain symptom free for many years but break down after some additional strain, and symptoms, once established, may persist indefinitely.

Pain in or around a joint gives rise to muscle spasm in the attempt to protect the joint from strain. The spasm may be localized at first to the deep muscles which span a single joint, but later it spreads to the more superficial and longer muscles that cover a number of joints and the pain becomes more widespread. Protective muscle spasm continues as long as the joint lesion remains unrelieved and a vicious circle is established—pain—protective muscle spasm—pain.

Pain may be of any degree from a mild ache to disabling severity. In the earlier stages there is often freedom from pain on getting up in the morning, but backache develops during the day; it is made worse by fatigue and relieved by resting with the back supported. It is not accurately

abdominal muscles. Tenderness is greatest over the affected joints but after a time it becomes more diffuse. Pain is often widespread and may radiate to the groin and down the leg. Active and passive movements of the lumbar spine are greatly restricted and painful.

*Acute sacroiliac strain* is much less common than at one time was thought but it not infrequently occurs after parturition, and on first getting up after an abdominal operation. It is usually accompanied by less severe symptoms than acute lumbago. The patient complains of difficulty in sitting for long, of twisting round, and of turning in bed. Active movements of the spine are fairly free in the sitting position, but passive movements involving rotation of the ilium on the sacrum are painful. To differentiate pain originating in the lumbar and sacroiliac joints, one knee is bent up to touch the chest thus flexing the spine fully and fixing the lumbar joints; rotation of the ilium then moves only the sacroiliac joints (Fig. 39, p. 51).

**Treatment.** Manipulation of the lumbar spine and sacroiliac joints can be performed without an anæsthetic provided muscle spasm is not too great. The procedure is the same whether an anæsthetic is used or not, and it should always be carried out on a firm couch or table because serious accidents have been reported from unskilled manipulation with the patient on a soft mattress. The patient is placed in the position illustrated in Fig. 38 and, when fully relaxed, a slight downward thrust is given to the ilium. The amount of force used must be controlled, especially when the patient is anæsthetized. Occasionally the reverse movement, backward rotation of the ilium, is required. This is done with the patient lying on his side and the legs flexed; the anterior superior spine is pulled backwards with one hand whilst the ischial tuberosity is thrust forwards with the other.

## CHRONIC BACK PAIN

Chronic backache is one of the commonest complaints met in practice and its causes are so diverse as to make systematic description more than difficult. The symptoms have little variety, physical signs are few, radiological findings are equivocal and pathological information is negligible. There is little agreement as to ætiology which is often speculative, and as to treatment which is usually empirical. The situation is further obscured by the psychological aspect which intrudes with every patient either as an ætiological factor, or because of the mental effect of long-standing pain. The confusion is reminiscent of the state of affairs regarding sciatic pain only a few years ago before the significance of intervertebral disc lesions was appreciated. This same lesion is now known to be a cause of back pain even when there is no sciatica, and it may well be that in time there will be comparable clarification. It is not, however, likely that disc lesions will be invoked as the explanation of all cases of chronic backache although they may account for a considerable number.

There are many schools of thought about back pain, particularly low back pain, each with a voluminous literature, and each emphasizing a different feature almost to the exclusion of all others. Some regard the psychological aspect as paramount, some incriminate mainly the viscera,

**Congenital Deformities.** Minor abnormalities of the vertebræ are extremely common and are present in more than 50 per cent. of all people. There is some evidence that they occur more frequently in painful than in painfree backs, and that they do play a part in the production of backache.

Asymmetry of the intervertebral articulations is common. The articular surfaces in the lumbar region are normally placed approximately in the sagittal plane to facilitate flexion and extension, but sometimes one *or more are placed obliquely. An element of rotation is therefore super*imposed on the normal movements and abnormal strains are introduced (Fig. 36).

The number of lumbar and sacral vertebræ varies. Normally there are five lumbar and five sacral vertebræ, but sometimes the arrangement is four lumbar and six sacral, or six lumbar and four sacral. An additional



FIG 37 Unilateral sacralization of the fifth lumbar vertebra

lumbar vertebra increases the length of the most mobile part of the spine, and therefore the leverage on the lumbosacral joint. An additional sacral vertebra is seldom of significance provided the whole of the fifth lumbar is [illegible]

transverse processes of the fifth lumbar vertebra to be large and linked to the sacrum by a diarthrodial joint (Fig. 37). The axis of movement during side-bending is then shifted from the sagittal plane to this joint and the excursion of the opposite side of the vertebra is increased. This may cause strain, and consequently pain, on the side opposite to the sacralization. The additional joint is also subject to the same causes of pain as any other joint.

localized, and is not reproduced by passive movements if examination happens to be made at a moment when there is no pain. The tendency over years is for the pain to become gradually worse and more continuous until eventually it is constant. Not infrequently a minor strain causes an exacerbation that brings the patient to consult his doctor.

**Muscular Fatigue.** The chronic fatigue of the long years of war has left its mark on the female members of the community in Great Britain. Even in the post-war period there is little relief and constant queueing is often the last straw that breaks a tired back. Amongst some sections of the population, especially women, under-nutrition may be an aggravating factor. Other precipitating causes are parturition followed by too early a return to the onerous duties of a working housewife, and prolonged recumbency during illness or after operation, particularly an abdominal operation, without adequate rehabilitation.

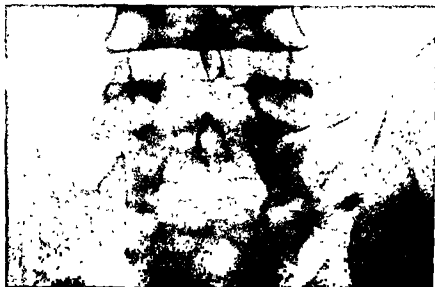


FIG 36 Asymmetry of the lumbosacral joints

**Postural Defects.** The posture of people with a poor habitual stance is such that the joints are near to one extreme of the range of movements, and this reduces the excursion of the joints before the ligaments come under tension. Postural defects are not necessarily accompanied by pain, but it often happens that a minor illness or some unusual strain precipitates the onset of symptoms. Those of slender build are more prone to this type of disorder, and stiff backs cause more trouble than supple ones.

Many patients with a bad posture and chronic backache complain also of abdominal symptoms. The abdominal symptoms are sometimes attributed to visceroptosis, and the visceroptosis is alleged to cause backache, but there is no need to assume a causal relationship. The faulty body mechanics, the visceroptosis, constipation, indigestion, backache and the accompanying general fatigue and ill-health are all part of one syndrome. It is a false approach to try to cure backache by a surgical attack on the abdomen, or by embarking on the Herculean task of cleansing the colon.

Ankylosing spondylitis, at an early stage when only the sacroiliac joints are involved, causes similar pain, but it is usually bilateral and the X-rays show definite changes (p. 81).

Conservative treatment and manipulation are without permanent benefit and arthrodesis of the joint is usually necessary (p. 60).



FIG. 39 Only the sacroiliac joint is moved because the lumbar spine has been fully flexed by bending up the right leg

## Myofascial Pain

Localized painful and tender areas in muscle, tendon and fascia are a very real cause of pain but the pathology is quite unknown. The terms "sensitive deposits" and "fibrositis" which are often used to describe them are misleading because there are no deposits and there is no inflammation. Areas of myofascial pain occur chiefly in connection with the extensor muscles of the trunk, sometimes as an isolated phenomenon, but often when there is muscle spasm due to another condition such as osteoarthritis of an underlying joint, or interveterbral disc protrusion.

Various explanations have been suggested :—

(*a*) Inflammation around sensory nerve endings: there is no histological evidence of this.

(*b*) Local metabolic changes in the tissue fluids around sensory nerve endings: that permanent relief often follows local infiltration with saline or novocain is in favour of this theory.

(*c*) Local areas of spasm involving only a few muscle fibres: alterations in electromyograms have been observed.

(*d*) Focal sepsis: the association is often noticed but a causal relationship is seldom proved.

(*e*) A "rheumatic" manifestation: it adds nothing to our knowledge to attribute this condition to "rheumatism" which is just as vague a concept.

**Acquired Deformities.** These give rise to back pain for the same reason as postural defects—the mechanical disadvantage at which the back is working causes undue strain during times of stress, usually at the site of a change in curve. Adolescent kyphosis, structural scoliosis, deformities of the hip, etc., are, therefore, frequently associated with back pain.

**Acute Strain.** In the absence of treatment an acute strain may fail to resolve and become chronic. The symptoms diminish in intensity after the initial acute phase but a lesser degree of backache continues indefinitely.

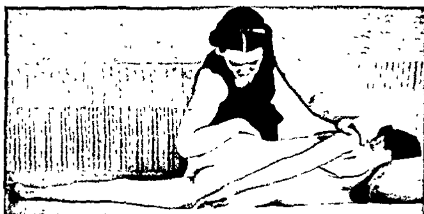


FIG. 38 Forward rotation of the left sacroiliac joint and lumbar spine (cf Fig 39)

Pain is not constantly present but is subject to exacerbations, particularly after exercise, and may radiate widely. The pathology is obscure but it is possible these cases are amongst the few in which there really are ligamentous adhesions.

Chronic symptoms resulting from acute strain occur most frequently in connection with the sacroiliac and lumbosacral joints, but the cervical and dorsal intervertebral joints and the costo-vertebral joints may also be affected. Pain due to chronic sacroiliac or lumbosacral strain may have a wide distribution in the back, and it is sometimes referred to the outer side or back of the thigh, and to the groin. The point of greatest tenderness is usually below the posterior superior spine of the ilium, or in the lumbosacral angle, and passive rotation is painful. Rotation with the spine in extension is painful with both lumbosacral and sacroiliac lesions (Fig. 38), but rotation in *flexion* affects only the sacroiliac joints (*Fig. 39*).

## Sacroiliac Inflammation

Chronic inflammatory changes in the sacroiliac joints are by no means uncommon but the ætiology and pathology are obscure. At operation the joint space is found to be partly obliterated by an irregular layer of fibrous tissue which is adherent to the articular cartilage of both sides. The condition is usually unilateral, and there is often a history of an initial attack of severe pain that has gradually subsided leaving a residual chronic pain of lesser intensity. The pain is aggravated by exercise and relieved by rest, and on examination the signs are localized to the sacroiliac joint. X-ray examination may be negative or there may be some sclerosis of the ilium close to the joint.

## Osteoarthritis

The articulations between the vertebræ are of two distinct types; those between the bodies are symphyses, whilst those between the articular processes are diarthrodial joints. Osteoarthritis is a disorder of diathrodial joints, and since the lateral intervertebral joints are the only joints of this type in the spine, the term arthritis should be reserved for them. Symphyses are subject to an entirely different series of pathological changes which includes the formation of bony outgrowths and spurs on the bodies of the vertebræ (p. 76); to refer to these changes as arthritis is confusing an already complicated subject. Vertebral spurs may occur at the same time as true osteoarthritis but they are just as common in its absence; their presence is an indication of past or present disc trouble and they are not, per se, a cause of pain.

Osteoarthritis occurs most frequently in weight-bearing joints. The lumbar and dorsal intervertebral joints are not weight-bearing and are less frequently affected by osteoarthritis than is often suggested. Osteoarthritis of the spine results from the same causes as elsewhere, i.e. interference with the joint mechanics, and therefore it occurs when there is alteration in the alignment of the spine which prevents the opposing surfaces of the joints from fitting and moving congrously. Disturbance in the alignment by gross deformity, such as structural scoliosis, or unreduced congenital dislocation of the hip, results in many joints being involved; but when the alteration in alignment is localized, as in congenital asymmetry of an intervertebral joint, only one or two joints are affected. Incongruity of the joints also occurs when an intervertebral disc is reduced in thickness, and since lesions of the discs often cause lipping of the vertebral bodies, the frequent association of lipping with osteoarthritis is explained.

The intervertebral joints in the cervical region are placed in a more horizontal plane than those lower in the spine and carry part of the weight of the head. Osteoarthritic changes are fairly common, specially in association with fracture and with absorptive changes in the vertebral bodies. In advanced osteoarthritis of the cervical spine there may be root pain due to pressure on the spinal nerves as they pass through the intervertebral foramina, and this causes intractible peripheral pain of root distribution. It is doubtful if osteoarthritis of the low lumbar joints ever causes root pressure although at one time this was thought to be a cause of sciatica.

Osteoarthritis of the sacroiliac joints is rare and the slight lipping at the inferior borders of the joints often seen in radiographs seldom has any connection with pain.

The symptoms of osteoarthritis are pain and stiffness. The pain is worse on movement and after exercise; it is relieved by rest although it is often worse on first moving after resting for a while. It does not usually interfere with sleep, but with advanced disease it may be troublesome at night. Examination shows protective muscle spasm, tenderness, pain on active and passive movements of the affected joints, and a reduced range of movements. Neither the history nor the physical signs are precise

Areas of myofascial pain can be divided clinically into three groups according to their situation and the response to treatment.

(1) In the origin of muscle fibres arising directly from bone without intervening tendon. The common sites in the back are the origin of the glutei from the ilium and sacrum, the erector spinæ from the sacrum and the crest of the ilium, the quadratus lumborum from the twelfth rib, the serratus magnus from the ribs, and the supraspinatus and infraspinatus from the scapula (Fig. 40). Pain may be felt locally but it is often referred elsewhere and patients are not always aware of the existence of tender spots which have to be located by careful palpation. Pain from the gluteal region may be referred over the buttocks and down the leg, pain from the spinati to the shoulder, and from the serratus magnus down the arm.

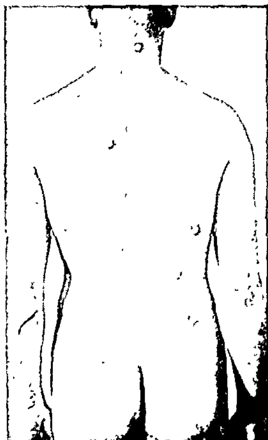


Fig 40 Myofascial tender areas

(2) In the fleshy bellies of muscles, usually the trapezius and the deeper cervical muscles.

(3) In the small, movable, encapsulated lobules of subcutaneous fat often to be found in the lower back. The lobules are usually painless but sometimes they are exceedingly tender. There is no histological difference between painless and painful lobules. Patients are usually aware of the tender lobule and the pain is seldom widespread.

The tender spots are quite small and often are first discovered by the physiotherapist during treatment. In young people with tenderness over the posterior part of the iliac crest, iliac apophysitis is an alternative diagnosis ; this condition requires no treatment and clears up spontaneously when growth is complete.

Treatment. Subcutaneous nodules can often be broken up by massage or, failing that, by an injection of novocain. Tender spots in the origin or the substance of muscles respond to infiltration with novocain. A long needle is inserted, moved about until the patient announces that the actual spot is touched and then the injection is made. A few cubic centimetres of fluid may be sufficient but it is advisable to infiltrate thoroughly the surrounding area and several injections at intervals of a few days are sometimes required. Injections should be followed by massage and general remedial exercises given, when possible before the effect of the local anæsthetic has worn off.

should also be treated actively by manipulation, massage and exercises. If there is no response to conservative measures, excision of the fragment or fusion of the affected vertebræ may be necessary, but this should only be undertaken as a last resort and after excluding all other possible causes for the pain.

## Root Pressure

Pressure on nerve roots may be caused by :—

*Intervertebral disc protrusion.*

*Collapse of the bodies of the vertebræ due to destructive diseases, osteoporosis or fracture.*

*Tumours of nerve roots.*

*Osteoarthritis of the intervertebral joints.*

*Spondylolisthesis.*

Most of these conditions are readily excluded by radiography and are discussed elsewhere.

Root pain is felt over the peripheral distribution of the root or roots concerned. Pain from the cervical roots is referred to the shoulder and arm, or to the back of the head when the only complaint may be of headache (p. 292). In the dorsal region, the typical "girdle" distribution sometimes draws attention to the diagnosis, but visceral disease may be so closely simulated that the appendix or heart is wrongly incriminated. Lumbar root pressure causes pain of femoral or sciatic distribution (p. 69).

The diagnosis is comparatively simple if the pain is of typical root distribution, except when visceral disease is simulated. The back should be examined whenever chronic appendicitis is suspected and an alternative diagnosis considered if there is tenderness to pressure on one of the low dorsal spinous processes and referred pain on passive movement.

## Intervertebral Disc Lesions

Intervertebral disc lesions may cause low back pain without associated sciatic pain (p. 64). The frequency with which this happens is uncertain but the present tendency is to attribute back pain increasingly to disc lesions and some surgeons have gone so far as to say they account for most of it. This extreme view cannot be accepted, but the possibility of disc protrusion must be considered when there is severe pain of unknown ætiology that fails to respond to conservative treatment.

A disc protrusion may cause back pain either by pressure on the longitudinal ligaments of the spine, or by pressure on nerve roots. An anterior disc protrusion pressing on the anterior common ligament may cause back pain but not root pain, but a posterior protrusion may give rise to either. The diagnosis is difficult in the absence of pain referred to the leg, but it may be inferred when there are recurring attacks of severe back pain with periods of freedom from symptoms. The only physical signs may be tenderness to pressure over the fourth or fifth lumbar spinous processes, and pain on flexion or extension of the back. Radiological examination is often negative.

enough for an accurate clinical diagnosis and a patient should never be told he has osteoarthritis unless there is definite evidence of involvement of the lateral intervertebral joints. The typical X-ray changes are irregularity in the outline of the joint, subchondral sclerosis and lipping (Fig. 41).



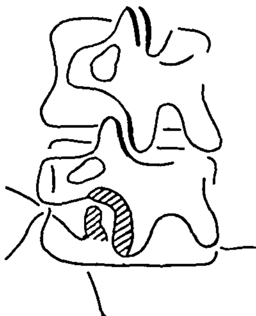


FIG 41 *Osteoarthritis of the lumbosacral joints The interpretation of oblique X-rays is discussed on page 96*

## Trauma

Trauma may be the primary cause of back pain, or it may precipitate the onset of symptoms when some other disorder is present which previously was relatively painless. Many patients attribute the onset of back pain to injury, perhaps only a strain from lifting a heavy weight, or a fall, but the history often shows that backache was present long before. The trauma may cause a sprain of a ligament, muscle or tendon, or it may damage an intervertebral disc, or fracture a vertebra; all these conditions except fracture are discussed elsewhere.

Compression fractures of the bodies of the vertebræ are usually obvious in X-rays, but there may be difficulty in recognizing minor fractures of the appendages which are commoner than is sometimes assumed. Fractures of the transverse processes, or avulsion of the tip, can usually be seen fairly easily, but fractures of the pedicles, articular processes or laminæ are hard to demonstrate and oblique films, preferably stereoscopic, may be required.

Fractures of the vertebral appendages often heal by fibrous union and the radiological appearances of fracture may persist throughout life. The symptoms usually disappear in time and it is more likely, even when there is evidence of old fracture, that chronic backache has some other cause. Tenderness and pain, including pain on the appropriate passive movements, must be correctly localized before a suspected fracture is incriminated.

Recent minor fractures should receive active treatment from the start and then the symptoms usually clear up rapidly. Chroni toms

## TREATMENT OF CHRONIC BACK PAIN

The approach to a patient with chronic back pain is beset with pitfalls and the greatest caution must be exercised because an initial error can precipitate the sufferer onto the downhill path of chronic invalidism. The therapeutic armamentarium ranges from physiotherapy to spinal fusion, and it may involve merely a few days rest, or a complete change in occupation and way of life may be necessary. No rule of thumb methods suffice, and no routine treatment can be laid down even for clearly defined pathological conditions; the hackneyed saying that it is the patient and not the disease that is treated is never more significant than here. Each individual is a separate problem the key to which is concealed in a complicated equation with his mental make-up, his environment and the physical lesion as the unknown factors. The greatest chance of success lies in the deliberate evaluation of the whole position by the patient's own doctor, and the greatest danger is a spot diagnosis by a specialist at a single interview.

An accurate diagnosis of the precise cause of pain is not always possible and therefore treatment must often be empirical. There are, in general terms, three methods of approach:—

(1) *Mobilization* which includes all measures directed to increasing the range of painless movements, principally physical therapy, exercises and manipulation.

(2) *Immobilization* which is intended to relieve pain by preventing painful movement.

(3) *A direct attack on the lesion.* This is only possible in certain instances, for example intervertebral disc protrusions, fractures of the vertebral appendages and myofascial pain, and even with these it is often desirable to try conservative treatment first and follow with more radical measures should it be necessary.

The majority of patients, whatever the cause of the pain, are first treated by mobilization, and when that has failed eradication of the lesion or immobilization are considered.

### Mobilization

Minor Backache without pathological changes in the ligaments or joints, for example when due to fatigue or postural defects, is often relieved by rest with heat and massage as adjuvants, but unless the underlying cause can be removed, recurrence is likely. Postural defects and minor fixed deformities can be corrected by remedial measures. When there is ill-health due to under-nutrition, or occurring after illness, the remedy is obvious but practical advice is difficult to give—what can be done to relieve the backache of a woman who works sixteen hours a day looking after her children, her husband and her home? People of sedentary occupation such as clerks and typists are often short of exercise and benefit from general physical training; "keep-fit" classes of one sort or another are available in many districts for both sexes and all ages, but the mistake of ordering exercises for an already overtired patient must not be made.

Disc lesions also cause chronic back pain by disturbing the alignment of the intervertebral joints. This happens particularly when the disc is greatly narrowed, and in an extreme example the joint may be completely dislocated (Fig. 42). In such cases backache is usually continuous although an exacerbation of pain often follows strenuous exercise. Misalignment can be demonstrated best by X-rays taken in an oblique plane which therefore should form part of the routine investigation of chronic back pain.



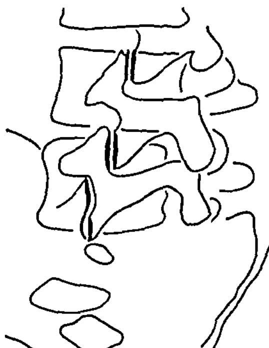


FIG. 42. Extreme narrowing of the lumbosacral intervertebral disc causing dislocation of the intervertebral joint. The pain was relieved by spinal fusion.

TREATMENT. It is usually impossible to diagnose disc protrusion during a first attack of acute back pain and the most useful treatment is manipulation. This often gives relief, at any rate temporarily, and it cannot cause serious harm if carefully and skilfully performed. Occasionally manipulation is followed by radiation of the pain along the leg, but even this may be turned to advantage because it makes the diagnosis certain, and operation, which is the only way of bringing about a permanent cure, can then be advised with less hesitation.

The operative removal of genuine intervertebral disc protrusions causing back pain can be as successful in the absence of sciatica as when sciatica is present, but the difficulty of diagnosis, and the complicating factor of intervertebral joint displacement, makes the results less certain. Displacement of the intervertebral joints, when it has been demonstrated radiologically, is an indication for operative fusion of the affected vertebræ, and there is a strong case for fusion whenever an operation for disc prolapse is performed for relief of backache. The best procedure, when there is severe pain and no response to conservative treatment, is to explore the fourth and fifth lumbar discs and perform a spinal fusion (p. 59).

trochanter, and attached to it are curved bands which pass over the iliac crests to give stability. Fixation at the upper end is by crutches under the axillæ, or straps round the shoulders. The upper and lower points of fixation are joined by a double bar shaped to the curves of the spine, and by a bar in each axillary line. The front of the support may be left open or an abdominal support of cloth or elastic can be fitted. A cervical extension to carry a band encircling the head can be added when necessary (Fig. 111).



Fig. 43 Spinal brace of the "Fisher" type

**Spinal Fusion.** Operative fixation of the vertebræ is indicated when there is severe pain and disability in a patient otherwise suitable for a major operation. It is the only method of immobilizing completely the affected parts of the spine and it can be relied upon to relieve the pain caused by movement. Failure means that the diagnosis was wrong, or that the operative technique was faulty and bony union has not been obtained.

Fusion is being practised with increasing frequency for low back pain, both with and without associated sciatic pain, and a number of new methods are under trial in the attempt to find one which removes the need for prolonged post-operative recumbency, and yet is reliable. Amongst the more promising of the newer operations are the H-graft, and screw fixation of the intervertebral joints. Both methods have the advantage of providing rigid fixation during the period of consolidation, and although neither is yet in general use, both are worthy of extended clinical trial.

SEVERE BACKACHE requires more energetic treatment, and as a rule the first step is manipulation under an anæsthetic using a similar technique to that already described for acute back strain (p. 46). This is followed by a course of deep massage, manipulation by the physiotherapist, and exercises. Massage must be really deep to reach the intervertebral joints and surrounding structures ; exercises are designed to maintain the full range of movement and improve muscle tone and control. Any myofascial tender areas that may be found by the physiotherapist should be marked and treated by infiltration with novocain.

*Osteoarthritis* is often helped by manipulation under anæsthesia, but it should be regarded as a preliminary mobilizing procedure and full benefit may only follow prolonged after-treatment. Heat and massage are given to relieve muscle spasm and immediately followed by passive movements and exercises. Short wave diathermy is usually the best method of applying heat. Exercises should be so arranged as to avoid pain and they must be continued for an indefinite period. Patients overweight need special attention and advice should be given as to the general regime, particularly the amount and type of exercise.

## Immobilization

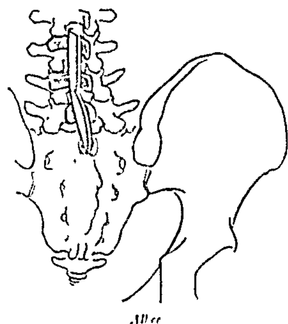
When mobilization fails to relieve the pain, or when there are frequently recurring attacks of pain, the alternative is immobilization (except if there is an intervertebral disc protrusion requiring removal, p. 71). Immobilization can be effected by wearing a spinal support or by spinal fusion.

**Spinal Support.** These are of value when the pain is not severe enough for operation, when the number of joints affected is too great for arthrodesis, and when the patient is mentally or physically unfit for a major operation. The trunk is a heavy object and strong machinery is necessary to support it or keep it still ; some supports are more effective than others but none prevent all movements of the spine.

A SURGICAL CORSET, if properly constructed, often gives a considerable measure of relief from low backache but it is safe to say that the pain is never entirely abolished. The basis of support is the pelvis and therefore the corset should fit firmly round the buttocks, but compression of the iliac crests is painful and must be avoided ; the stiffening in the back should not be placed centrally but on each side of the line of the spinous processes. Support for the lower abdomen should be designed so that the pull is exerted obliquely backwards and upwards, thus supporting and not merely compressing it. Pressure pads and truss-like appliances are harmful because they cause atrophy of underlying structures.

SPINAL BRACE. A rigid brace is very unpleasant to wear, and although it gives better support than a corset, it is not really efficient because of the difficulty in obtaining fixation to the thorax without compressing it.

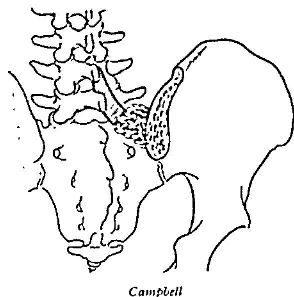
The Fisher type of brace is in common use in England (Fig. 48). The lower point of fixation is a pelvic band which encircles the pelvis at a level mid-way between the anterior superior spine of the ilium and the great



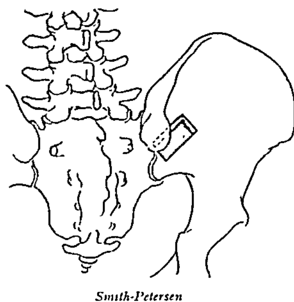
*Albee*



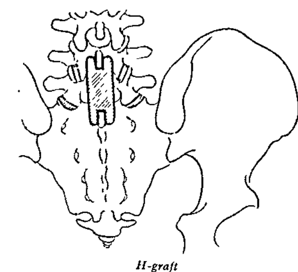
*Hibbs*



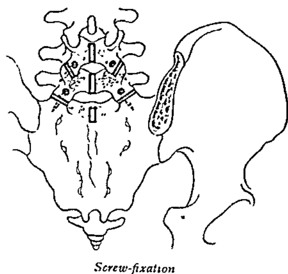
*Campbell*



*Smith-Petersen*



*H-graft*



*Screw-fixation*

FIG 44 Operations for spinal fusion

*Albee's* operation, or one of its variations, can be used for any part of the spine except the sacroiliac joints. The spinous processes and laminæ are fused together by tibial grafts fastened to them, or alternatively the spinous processes are split longitudinally and the graft placed therein. Firm apposition of the grafts with the host is ensured by wire or screw fixation. After operation the patient lies in a plaster bed for six weeks and then wears a spinal brace for about a year until fusion is complete.

*Hibb's* operation and others of this type combine intra-articular and extra-articular fusion. Multiple bone chips are raised from the laminæ and interlaced so as to unite into a solid mass. The lateral joints are excised and packed with bone chips, and the spinous processes may be "bent" down to bring them into apposition. Post-operative fixation as after Albee's operation is necessary.

*Campbell's* operation allows extra-articular fusion of the sacroiliac joint to be performed alone or in combination with the lumbosacral joint of the same side. A graft is cut from the posterior part of the iliac crest and placed in a bed prepared for it between the overhanging portion of the ilium and the sacrum. Fusion can be extended to include the lumbosacral joint by exposing the transverse process of the fifth lumbar vertebra and the lumbosacral articulation, and carrying the graft up to that level. Prolonged post-operative fixation is essential.

*Smith-Petersen's* sacroiliac fusion is performed by removing a rectangular plug of bone about 2 inches by 1 inch from the ilium over the joint; the anterior surface of the plug forms part of the posterior surface of the joint. The articular cartilage is removed from the plug and the exposed surface of the sacrum, and then the plug is replaced and firmly impacted with a punch. Plaster fixation after operation is unnecessary; the patient lies on his back on a firm mattress for four weeks and then is allowed up.

*H-graft.* The fifth lumbar spinous process is excised and the cortical surfaces are removed from fourth lumbar and first sacral spinous processes, and from the laminæ of the fourth and fifth lumbar vertebræ and the upper part of the sacrum. A rectangular graft of the exact length necessary is cut from the crest or the outer table of the ilium, or from the tibia, and a deep notch is made in each end of it. The fourth lumbar and first sacral spinous processes are then separated by forcible traction and the graft is placed between them. It is usual to pack the space between the laminæ and the graft with chips of cancellous bone, and some surgeons also excise the articular cartilage from the intervertebral joints and pack them with bone. The H-graft is fitted whilst the spine is in full flexion so that when it is extended the graft "takes the weight" and often gives immediate relief from pain. It also immobilizes the vertebræ for long enough to allow the chip grafts to fuse.

*Screw Fixation.* The cortical bone is removed from the laminæ and spinous processes of the affected vertebræ and the intervetrebral joints are excised. Screws 1 to 1½ inches long are passed from the laminæ through each of the joints into the pedicles, and chips of cancellous bone are packed into the joints and placed on the raw surfaces of the laminæ.

## SCIATICA

Sciatica is a symptom, not a disease. It is a symptom produced as a rule by mechanical interference with the trunk of the sciatic nerve or its roots at any point subsequent to their emergence from the spinal cord. Until recently there was great confusion about the ætiology of sciatica; a mechanical explanation was accepted only when there was an obvious cause like a massive pelvic tumour or a diseased vertebra, and the great majority of cases were regarded as inflammatory. Mixter and Barr's paper on intervertebral disc lesions, which was published in 1934, completely altered the position and since then it has become apparent that an overwhelming percentage are caused by disc protrusions. Primary "neuritis" and "radiculitis," once regarded as common, are now known to be rare causes of sciatic pain.

Although disc protrusions are responsible for a large proportion of cases of sciatic pain, it is always necessary to exclude other possible causes and an abbreviated list of them is given below.

Root Pressure:

| | |
|---|---|
| *In spinal canal.* | Intervertebral disc protrusion. |
| | collapse of bodies of vertebræ. |
| | tumours of nerve roots and meninges. |
| | spondylolisthesis. |
| *In neural canal.* | Tumours of nerve roots. |
| | Hodgkin's disease. |
| *In pelvis.* | Impacted tumours. |
| | local spread of malignant tumours. |
| | abscess. |
| *In buttock.* | Tumours of pelvic bones. |
| | soft tissue tumours. |

Primary Neuritis.
Pseudo-Sciatica.

*Pseudo-sciatica* is a complaint in which there is no direct interference with the nerve roots but pain is referred to the peripheral distribution of the sciatic nerve or the lesser sciatic nerve, usually from a myofascial tender area (p. 51). The pain is felt at the back of the thigh or leg and somewhat resembles that in sciatica; it is made worse by pressing on the tender spot but it is not increased by coughing or sneezing (i.e. raising the cerebrospinal pressure), and there are no organic motor or sensory changes. Infiltration with novocain always relieves the pain temporarily, and sometimes permanently. Similar "trigger points" are not infrequently found when there is true sciatica, and although treating them may lessen the severity of the symptoms, it will not relieve them entirely.

### Intervertebral Disc Protrusions

An intervertebral disc protruding in a posterior or postero-lateral direction may come into contact with the intra- or extra-dural portions of one or more spinal nerve roots causing lumbago and sciatica. There are

## COCCYDYNIA

Pain in the region of the coccyx occurs more frequently in women than men; moreover, women of neurotic personality are more often afflicted and this makes it harder to assess the importance of an organic lesion, and more difficult to treat it. The patient often attributes the trouble to a minor injury like a kick or a fall. The symptoms persist indefinitely and are annoying rather than incapacitating. The pain is worse when sitting than when standing, and sometimes when going upstairs, an action which involves the use of the gluteus maximus. Sometimes the only complaint is of a burning or pricking sensation.

The difficulty in treating coccydynia is due partly to inadequate examination. It is necessary to localize exactly the point of greatest tenderness by bi-digital examination with one finger in the rectum.

There are four types of coccydynia :—

(1) *Fracture.* The coccyx or the lower pieces of the sacrum are sometimes fractured by a fall or a kick. Diagnosis must be based on good X-ray evidence because variations in the shape of the coccyx and the number of segments composing it are common and may be mistaken for fracture on casual examination. Sharp forward angulation of the coccyx at the sacro-coccygeal joint is a frequent anatomical variation and is seldom due to injury.

(2) *Sacro-coccygeal Joint.* The ligaments of this joint may be strained by injury just as at any other joint. On bi-digital examination, movement of the coccyx causes pain which is felt at the joint and not where the fingers are pressing.

(3) *Myofascial Painful Areas.* These occur in the attachment of the muscles arising from the coccyx and in the ano-coccygeal body. Pain originating in the ano-coccygeal body is often felt diffusely over the perineum. Tender spots can be accurately localized and pain is caused by direct pressure, and not by movement of the coccyx.

(4) *Diffuse Pain* with no localizing physical signs. This is the most distressing form of coccydynia for all concerned. The pain is often described as burning in character, and there is no constant point of tenderness. Infiltration of the entire region with a local anæsthetic may fail to relieve the symptoms even temporarily. The pain is clearly of central origin and peripheral treatment is useless.

**Treatment.** Coccydynia so often occurs in neurotic subjects that the remarks already made about chronic backache apply with particular force. Organic lesions, however, must not be overlooked because they do respond to local treatment. Well localized tender areas usually disappear after infiltration with novocain or with a small quantity of proctocain, and sometimes manipulation of the sacro-coccygeal joint under anæsthesia is helpful.

Excision of the coccyx should only be advised in carefully selected patients and, on the whole, it does more harm than good. It is indicated, after conservative treatment has failed, when there is a fracture, and when there is pain on movement of the sacrococcygeal joint.

About half the patients with sciatica have had an injury shortly before the first attack of pain. Subsequent attacks may start after a minor twist of the back, for example when gardening, or there may be no apparent reason. A history of trauma does not help with diagnosis because minor injuries are very common in the normal course of life, and because the incident which injures a disc may be widely separated in time from the actual protrusion or the onset of symptoms.

**Symptoms.** PAIN is the outstanding feature, the one thing that really matters to the patient. There may be only a dull ache, or there may be a stabbing, neuralgic pain that shoots the length of the limb with searing agony. At its least, the pain is a constant source of annoyance; at its worst, it is of almost intolerable severity, all ordinary movements are prevented, the victim changes position only slowly and deliberately, rest is impossible and even a cough is fearful.

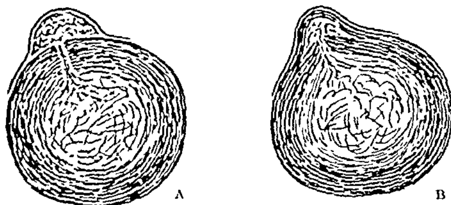



FIG 48 Intervertebral disc protrusions (cf Fig 50)
A Consisting mainly of nucleus pulposus
B Consisting mainly of annulus fibrosus

*After Bradford and Spurling.*

Pain may be felt in the back or in the area of distribution of the sciatic nerve, but more frequently it is in both at once with one or other predominant. The pain is often described as commencing in the lumbosacral angle and radiating through the buttock and down the back or outer side of the thigh to the knee; thence it spreads down the calf to the ankle and through the heel to the sole, or to either side of the dorsum of the foot; sometimes it shoots along the leg, and sometimes it is felt as a spasm gripping the calf like a vice. It is made worse by walking or any form of exercise, and by straining, coughing or sneezing. Rest generally relieves it somewhat although spontaneous movements during sleep may cause a spasm. It is generally eased by flexion of the knee and hip, and certain "trick" postures such as rotation of the back combined with extension of the hip on the bad side, or elevation of both arms, occasionally give relief.

PARÆSTHESIÆ are very common. Numbness, tingling and pins and needles may be felt in any part of the limb, particularly the foot, and are increased by those movements which cause pain.

WEAKNESS of the muscles of the buttock or calf is sometimes considerable enough to be noticed by the patient.

two types of protrusion, one consisting mainly of nucleus pulposus, and the other mainly of annulus fibrosus, but they are not always clearly differentiated. The ætiology and pathology are discussed on p. 73.

The commoner type is composed of a core of nuclear material covered with a thin layer of annulus fibrosus bulging backwards into the spinal canal (Fig. 46a). The protrusion is under tension and the core extrudes when the annulus is incised at operation. Occasionally it bursts spontaneously and nuclear material is found free in the spinal canal. One or more nerve roots may be in contact with the protrusion and then movement of the back or traction on the nerve causes pain. This is the explanation of pain on straight-knee leg raising, on flexing the neck, and on coughing, straining and other activities which raise the pressure of the cerebro-spinal fluid. Variation in the relative positions of the protrusion and the nerve roots probably explains why different patients with sciatica find different postures more comfortable.

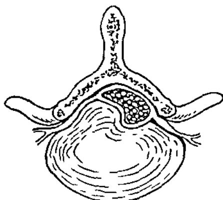


FIG 45 Intervertebral disc protrusion impinging on a nerve root

The other type of protrusion consists mostly of degenerate and partly fragmented annulus (Fig. 46b). With recent lesions pain is produced in the same way as the previous type, but in old standing protrusions there is often much fibrosis involving the surrounding extradural tissues and adjacent nerve roots. The nerve roots are anchored firmly and pain is caused during movement because they are stretched instead of gliding freely. Very large, centrally placed protrusions may compress the entire cauda equina causing partial paraplegia.

## Clinical Features

Men are affected more frequently than women, possibly because they are more exposed to trauma. The chief complaint is of pain which in most cases is first felt in the back and later radiates down the leg; sometimes, however, it starts in the leg. The onset may be abrupt, the pain reaching its greatest intensity very quickly, or it may start as a mere ache and increase gradually to a climax. Very often there are repeated attacks of lumbago without sciatic pain before the latter is finally felt. Repeated attacks of sciatica with intervals of comparative freedom are common, and sometimes a single attack of lumbago, or lumbago and sciatica, is followed by many years of complete freedom before another bout supervenes.

than limitation of extension, but occasionally flexion is fairly free and extension is more difficult. Side bending and rotation are not usually restricted in both directions by the same amount; sometimes movement is more free towards the affected side, and sometimes away from it.

Movements such as undressing, getting up from a chair and lying down are made with great caution, and it may be impossible for the patient to lift the bad leg on to a high couch without the aid of his hands. He lies with hip and knee flexed and often is unable to place the leg flat. Turning over is a matter of difficulty and the whole trunk is moved as a solid piece. Lying prone is painful unless the hip can be fully extended and it may be necessary to place a pillow under the pelvis during examination.

TENDERNESS. Pressure on the fourth or fifth spinous processes is nearly always painful and may cause pain to be referred to the leg. There is often tenderness at the lumbosacral angle, over the sciatic notch, and along the course of the sciatic nerve in the thigh and calf, and sometimes there are tender spots in the muscles on the dorsum ilii.

*Lasègue's Sign* (Fig. 31, p. 40). Pain is almost invariably caused by raising the straight leg when lying supine. Sometimes it begins when the foot has only been lifted a few inches from the couch, but sometimes the leg can be raised 70° or 80°. Raising the sound limb whilst the affected limb remains flat may also cause pain. The pain has the same character and distribution as that previously experienced by the patient and it must not be confused with the feeling of tightness behind the knee and thigh that is normally felt when straight leg raising is forced.

Pain is also caused by raising the straight leg to a point just short of that which produces pain and then dorsiflexing the foot at the ankle, because this increases the tension on the sciatic nerve. Pain is sometimes caused by flexing the neck whilst the leg is raised, probably because the dura mater is dragged upwards thus increasing pull on the nerve root. Straight leg raising is painful in disorders of the lumbosacral and sacroiliac joints as well as in sciatica, but it is not aggravated by dorsiflexion of the foot or flexing the neck.

CENTRAL NERVOUS SYSTEM. Objective motor and sensory changes are frequently, but not invariably, present. The usual motor signs are wasting and loss of power, but occasionally there is fibrillation, and in rare instances complete paralysis. The muscles mainly affected are the triceps suræ and the extensors of the toes.

The chief sensory changes are cutaneous hyperalgesia and hypoæsthesia. Sometimes both are present, sensitivity being increased in some areas and reduced in others. The areas of altered sensation when accurately mapped are of assistance in determining the level of the protrusion (Fig. 48).

The tendon reflexes are often disturbed. The ankle jerk on the affected side may be diminished or absent; the knee jerks are usually brisk, and occasionally increased in the bad leg. The plantar responses are flexor.

LUMBAR PUNCTURE. The findings are positive only when there is a complete or nearly complete subarachnoid block. The Queckenstedt

**Physical Signs.** Posture. The normal lumbar concavity is often absent or reversed, and frequently the spine is inclined to one side (*sciatic scoliosis*). The patient leans slightly forwards and most of the weight is carried on the sound leg. The affected leg may be slightly flexed at the hip and knee, and the heel raised from the ground.

"Sciatic scoliosis" is not a true lateral curvature but a list of the trunk to one side at the lumbosacral junction (Fig. 47). The position is adopted unconsciously, presumably because it relieves the pain, and is present when sitting or lying as well as when standing. The direction of inclination may be either towards or away from the affected side and is probably determined by the relation of the nerve root to the protrusion. Occasionally,

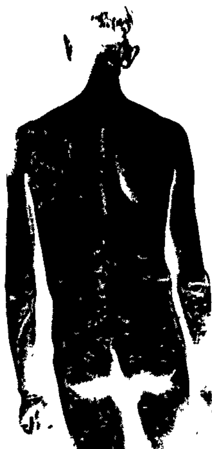


Fig 47 "Sciatic scoliosis"

when the protrusion is nearly central, the patient is able to change the inclination from one side to the other voluntarily (*alternating sciatic scoliosis*); this is effected by leaning forwards and giving the back a sort of wriggle. The site of pain changes and moves sometimes to a different part of the same leg, and sometimes to the other leg. Alternating sciatic scoliosis is invariably caused by an intervertebral disc lesion.

Movements. There is obvious spasm of the lumbar muscles. When standing, all movements of the lumbar spine are restricted, and pain is felt at the extremes of movement; as a rule limitation of flexion is more marked

When the fifth lumbar root is involved the pain passes down the back of the calf to the heel and the sole of the foot; the sensory changes are at the outer side of the thigh and knee, in front of the shin and on the inner part of the foot, and there may be weakness of dorsiflexion of the big toe. The first sacral root causes pain at the outer side of the calf and foot, and sensory changes in the same area; there may be weakness of plantar flexion of the foot and the ankle jerk may be diminished or absent.

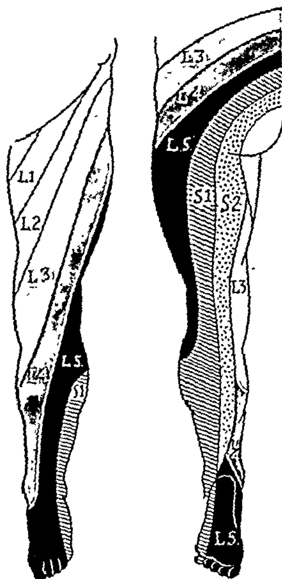



Fig 48. The dermatones of the leg (modified from Keegan)

Radiological narrowing of an intervertebral space is some indication of the level of the affected disc, but protrusions do not always cause a significant amount of narrowing. Narrowing is often present when there are no symptoms attributable to disc prolapse, and sometimes a protrusion is found at operation at one level when the X-rays show narrowing at another.

phenomenon is then positive, the protein content of the cerebrospinal fluid is increased, and it may be coloured yellow (Froin's syndrome).

RECTAL examination is necessary to exclude intra-pelvic causes of pressure on the sciatic nerve.

**X-rays.** Disc protrusions are not always accompanied by demonstrable X-ray changes, and although there may be narrowing of one or more intervertebral spaces, and also lipping of the bodies, similar changes are often found when there is no protrusion. Radiographic examination is, however, essential to exclude disease of the vertebræ and to demonstrate the condition of the intervertebral joints.

The routine investigation of sciatica formerly included myelography using a contrast medium (Fig. 49), but this procedure is no longer in general use because the findings are not entirely reliable. A negative myelogram is sometimes obtained when a protrusion is subsequently found at operation, and an apparently positive finding may be due to an artefact.

## Diagnosis

True sciatica is caused in all but an insignificant number of patients by mechanical interference with one or more nerve roots, and in at least 80 per cent it is due to intervertebral disc protrusion. The presence of a disc protrusion can safely be inferred when other disorders such as disease of the bodies of the vertebræ, spondylolisthesis and intra-pelvic tumours have been excluded. It is doubtful if osteoarthritis alone ever causes root pressure in the lumbar region, and thickening of the ligamentum flavum is no longer accepted as a cause of sciatic pain. Pain is not a prominent feature of primary neuritis or radiculitis. Disorders of the lumbosacral and sacroiliac joints may produce a posture rather similar to that in sciatica but the pain is not increased by dorsiflexion of the foot during straight leg raising, nor by coughing, and there are no organic sensory or motor changes in the nervous system. The pain in pseudo-sciatica is less severe than with true sciatica, and relief is given by infiltrating the "trigger point' 'with novocain.

**Level of Lesion.** The greatest number of disc protrusions occur at the fifth lumbar disc (i.e. that between the fifth lumbar vertebra and the sacrum), and there are nearly as many at the fourth lumbar disc, but only about 5 per cent are at the third lumbar. Double lesions in which there is protrusion of more than one disc, usually the fourth and fifth lumbar discs, are present in about 8 per cent of patients (Burns and Young). The affected root or roots are often indicated with some precision by the distribution of pain and the physical signs, but this does not give completely reliable information as to the level of the protrusion because a protrusion may be in contact with more than one root. The first sacral root crosses the fifth lumbar disc, and both fifth lumbar and first sacral roots cross the fourth lumbar disc. The first sacral root, therefore, may be in contact with a protrusion of either disc, and involvement of both roots may be due either to a protrusion of the fourth lumbar disc alone, or of both fourth and fifth lumbar discs.

space allowing the protrusion to return, and therefore manipulation is more likely to be successful during the first attack than in subsequent attacks when there has been time for the protrusion to become fixed by fibrosis. Forced flexion is avoided because it may increase the size of the protrusion.

Epidural injection of a large volume of fluid is sometimes helpful, probably because it displaces the nerve root from contact with the protrusion. It is conveniently carried out whilst the patient is anæsthetized for manipulation. The technique is simple but requires strict aseptic precautions. With the patient prone, two fingers of the left hand are placed on the cornua of the sacrum; a 15 cm. needle of large bore is introduced 2 cm. lower and directed cranially into the sacral canal. About 100 ccs. of saline are then injected rapidly with as much pressure as possible.

**Bed.** Rest in bed brings relief to a majority of sufferers from sciatica although a high proportion eventually relapse. Rest should be continued for at least three weeks during which time the patient is not allowed out of bed at all, except perhaps for defæcation because the strain of using a




FIG 50 Disc protrusions removed at operation (cf Fig 46). Left—mainly annulus fibrosus Right—mainly nucleus pulposus.

bed pan may be greater than moving to a commode. Sedatives are given freely, and warmth is essential—a hot water bottle or an electric pad behind the back are most comforting.

**Operation.** The percentage of really successful operative results is high and there are few complete failures. The operation is not severe and the operative mortality is negligible, the risk in skilled hands being hardly greater than that of the anæsthetic. The majority of patients are entirely relieved of root pain, and although a proportion have some backache for a time, they are able to return to their previous occupation unless it entails very heavy work. Some patients are left with occasional mild root pain or paræsthesiæ, especially after exercise, but it tends to diminish gradually. Failure to relieve sciatic pain is due to an error in operative technique or to an undiscovered double lesion; subsequent recurrence is due to incomplete removal of a protrusion or another occuring later at a different

## Treatment

The treatment of sciatica is at present in a phase of change brought about by modern views of the ætiology. Before disc lesions were recognized conservative treatment was the rule, and it must be remembered that it was often successful; operation was reserved for the most intractible cases, and at that time it consisted either of "decompression" of the nerve root, or of spinal fusion. The success of operative removal of the protrusion has resulted in this operation being performed with steadily increasing frequency, but the indications are not yet clearly established. Some surgeons operate more freely than others and regard operation as the natural sequel to a diagnosis of sciatica. Often, however, the pain is hardly of a severity to warrant a major operation, and even patients with severe pain may recover spontaneouslyand remain free of symptoms for a long time.

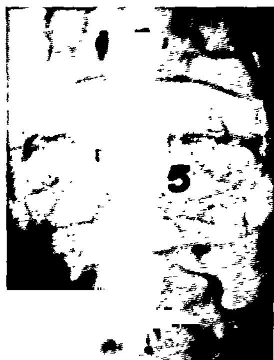



FIG 49 Myelogram The indentation on the left side of the column of pantopaque is made by a protrusion of the fifth lumbar intervertebral disc

The treatment of sciatica due to causes other than disc lesions depends on the pathology and does not require separate discussion here.

The treatment of disc lesions is conveniently divided into three categories, ambulant, bed and operative.

**Ambulant.** This may be tried when the pain is not too severe, specially in non-manual workers. A régime is instituted which combines as much rest as possible with sufficient controlled exercise to maintain the power of the spinal muscles. Heat and massage help to relieve muscle spasm, and exercise should avoid movements that increase the pain. A sedative may be necessary to ensure proper rest at night.

Manipulation under an anæsthetic is often helpful and sometimes dramatic. It is thought that hyperextension widens the intervertebral

CHAPTER III

# THE SPINE

## THE INTERVERTEBRAL DISCS

LESIONS of the intervertebral discs play a major part in the ætiology of a number of disorders notably sciatica, adolescent kyphosis, senile kyphosis and lipping of the vertebræ. The clinical aspects of these conditions are discussed under their separate headings, but the pathological anatomy, which is still imperfectly understood, is more conveniently considered independently. The following simplified account is based on Beadle's and on Bradford and Spurling's monographs.

### Anatomy

**Vertebræ.** The upper and lower surfaces of the developing vertebral bodies are each covered with a thin plate of hyaline cartilage which may be regarded as an epiphysis. Growth takes place over the whole plate, but all the plate does not ossify on completion of growth, only a ring around the circumference. Ossification in the ring commences at a number of centres about the ninth to eleventh years, earlier in girls than in boys, and it fuses with the body about the twenty-second year. The central part of the plate, and also an extension to the posterior margin of the vertebral body where the ring is absent, remain permanently cartilaginous.

**The Intervertebral Discs** develop from the primative mesenchyme around the notochord. The notochordal cells degenerate and become surrounded by a quantity of mucoid material which, in turn, is invaded by fine strands of fibrocartilage; the peripheral portion of the mesenchyme differentiates into the annulus fibrosus. The fully developed disc consists of two parts, the nucleus pulposus and the annulus fibrosus (Figs. 45 and 46, p. 65).

THE NUCLEUS PULPOSUS is contained in an envelope of fibrocartilage which blends with the inner layers of the annulus. It is composed of mucoid material interlaced with fine fibres of fibrocartilage extending inwards from the envelope, and embedded in it are a few groups of cartilage cells and occasional degenerate notochordal elements. The nucleus is in contact above and below with the hyaline cartilage plates on the faces of the vertebræ, and it is confined peripherally by the annulus.

THE ANNULUS FIBROSUS consists of densely interwoven bundles of connective tissue amongst which are some elastic fibres and some areas of fibrocartilage. The outer laminæ are more clearly differentiated than the inner; the inner laminæ decrease in connective tissue and increase in fibrocartilage content as the centre of the disc is approached until they

level. Failure to relieve back pain is due to lack of appreciation of intervertebral joint changes requiring spinal fusion.

The relief of pain is so dramatic, and most patients are so grateful, that operation is being advised with increasing frequency. The definite indications are frequently recurring severe attacks of sciatica or lumbago, failure of rest in bed to give relief, and a return of pain immediately after getting up from a period of rest. Operation is performed primarily because of pain, and with increasing experience the amount of pain and incapacity judged necessary to indicate operation is becoming less. The chief contraindication to operation is emotional instability but allowance must be made for the mental effect of long continued, severe pain.

The operation consists in removal of the nucleus pulposus, the protruding annular portion of the disc, or both (Fig. 50). Many surgeons approach the disc between the laminæ and remove at most a nibble of bone, but some consider it advisable to have a wider exposure and perform a hemilaminectomy. The patient should remain in bed after operation for three weeks ; graduated exercises are commenced after a few days and continued until there is full recovery. It is important to prevent too early a return to work and to insist on full rehabilitation to the degree of fitness demanded by the occupation.

Fusion of the fourth and fifth lumbar and the first sacral vertebræ at the same time as removal of the protrusion is desirable when there is misalignment or osteoarthritis of the intervertebral joints. This occurs chiefly in middle-aged and elderly people when a disc lesion has been present for a long time and the intervertebral space is greatly narrowed, but lesser degrees causing intractible backache are often present in younger people. The older methods of spinal fusion entail some months in bed followed by the use of a spinal brace for about a year, and this has prevented the operation being performed as often as it should be. However, other methods of fusion which do not require prolonged post-operative recumbency, such as the H-graft (p. 60), are now under trial, and if they prove successful, as seems probable, the indications for fusion are likely to be extended.

may cause the nucleus to extrude through the annulus, or else cause the damaged portion of the annulus itself to prolapse (Fig. 51c). Such protrusions impinging on the spinal nerve roots, when occurring in the lumbar spine, are the commonest cause of *sciatica*, and in the cervical region they are a frequent cause of pain in the arm.

**Dehydration of the Nucleus Pulposus.** The fluid content of the nucleus pulposus normally diminishes with age, and it appears also that protrusion of the nucleus, even partial extrusion into bone or into the substance of the annulus, accelerates the process. Dehydration of the nucleus, whether due to increasing age or to protrusion, reduces its elasticity and this interferes with the transmission of stresses rendering the annulus more liable to injury.

Reduction in the buffering action of the nucleus also interferes with the even distribution of pressure over the bodies of the vertebræ. Pressure

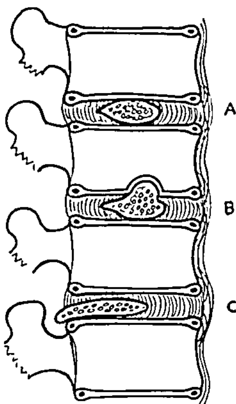



Fig 51 Intervertebral discs.
A Normal
B Schmorl's node
C Posterior nuclear protrusion

on the anterior portions of the bodies is increased, but the posterior portions are protected by the support of the neural arch and intervertebral joints.

The reaction of the vertebræ to increased pressure varies with the condition of the bone at the time :—

Adolescence. Development is not complete and increased pressure on the front of the bodies retards growth and causes them to become wedge-shaped. This is a typical feature of *adolescent kyphosis* (p. 77). Disturbance in the regular ossification of the epiphysial ring can be seen

finally merge with the containing envelope of the nucleus. Fibres of the annulus are attached to the bony epiphysial ring and to the cartilage plates thus binding the vertebræ together.

The nucleus is under tension and bulges when the annulus is incised. Bradford and Spurling consider the tension is due to pressure of the elastic fibres of the annulus and not, as is often stated, to an expansile force within the nucleus. The nucleus obeys the laws of fluids and this enables it to fulfil its functions of distributing stresses evenly over the whole of the opposing surfaces of the vertebræ, and of acting as a shock-absorber when a sudden force is applied. The stresses to which it is subjected are considerable and in some circumstances may be as much as a ton.

## Pathology

The factors concerned in bringing about pathological changes in the intervertebral discs are :—

(*a*) Injury to the hyaline cartilage plates.
(*b*) Injury to the annulus fibrosus.
(*c*) dehydration of the nucleus pulposus.

The exact details of the mechanism are to some extent speculative and various processes are not always as distinctly separated as the following account suggests.

**Hyaline Cartilage Plates.** Injuries to the hyaline cartilage plates occur chiefly during adolescence and less frequently in adults.

ADOLESCENTS. The way in which the plates are damaged is not known for certain but it is thought that flexion injuries, either a single major injury or repeated minor ones, may play a part. Lambrinudi has drawn attention to the frequency with which adolescent kyphosis and short hamstrings are associated, and he suggests that repeated forced attempts to touch the toes during "gym" and similar activities may sometimes cause damage.

When a cartilage plate has been injured, the nucleus pulposus is able to permeate through the resulting crack into the spongy bone of the vertebra. The bone reacts by forming first a shell of hyaline cartilage over the prolapsed tissue, and later a layer of compact bone around the cartilage (Fig. 51b). The resulting cup-shaped depressions in the vertebral bodies, known as *Schmorl's nodes*, are often seen in adolescent kyphosis.

ADULTS. It has long been observed that occasionally, after trauma, one vertebra slowly becomes wedge-shaped (*Kummell's disease*). There is no radiological evidence of injury to bone immediately after the accident and the process of compression is gradual. A possible explanation is that the hyaline cartilage plate is fractured at the time of injury and this permits extrusion of the nucleus into the substance of the bone causing trabecular absorption and collapse. It appears that adult bone does not react in the same way as adolescent bone and the protrusion is not walled off.

**Annulus Fibrosus.** Injury to the annular portion of the disc is thought to occur chiefly during adolescence and early adult life, probably as the result of flexion violence. Symptoms do not necessarily follow immediately, but sooner or later, possibly after years, an additional strain

penetrate the spongy bone and cause trabecular absorption. The discs sometimes ossify, especially anteriorly, thus fusing the front of the bodies together.

This condition is in marked contrast to that in which the vertebræ are atrophic but the intervertebral discs are healthy and the cartilage plates intact. The discs then expand without destroying the structure of the bone (*senile osteoporosis*, p. 81).

## ADOLESCENT KYPHOSIS

This is a common condition of which the outstanding feature is the gradual development of dorsal or dorsolumbar kyphosis. It is caused by the pathological changes in the vertebræ and the intervertebral discs which, as described in the preceding section, cause the vertebræ to become wedge-shaped.



FIG 53 Adolescent kyphosis in a girl aged 17 who had no pain There is wedging of the vertebræ, the intervertebral spaces are narrow, and small Schmorl's nodes are visible.

### Clinical Features

The onset is during adolescence, but the deformity persists throughout life and it was observed in nearly 2 per cent of some 500 "normal" young adults examined by the author. The condition is usually said to occur with greater frequency in males than females because they are more exposed to trauma, but Burns and Ellis found females to preponderate in the proportion of two to one in a large series.

The deformity commences at twelve to fifteen years of age, often before there is any pain, and frequently it is first discovered during a

radiologically; it appears fragmented, specially the anterior part, and sometimes ossification is suppressed causing a distinct notch in the anterior corner of the body. This condition was described by Scheuermann, with whose name it is associated, but he regarded it as a form of osteochondritis juvenilis.

THE HEALTHY ADULT VERTEBRA does not collapse under the additional strain but reacts by the formation of new bone at the periphery where the fibres of the annulus are attached. The resulting *spurs, lips and beaks* are evidence of disorder of the intervertebral discs and not, as is often said, signs of osteoarthritis (Fig. 52).



FIG 52 Lipping of the bodies of the vertebræ
This is *not* evidence of osteoarthritis

THE ELDERLY. When the bodies of the vertebræ are somewhat porotic, as is not uncommon, the increased pressure causes them to absorb anteriorly and become wedge-shaped (*senile kyphosis*, p. 79). It is possible that the hyaline cartilage plates also fissure allowing the nucleus pulposus to

hollow in the bed corresponding to the kyphus is gradually filled with padding over a period of months; this extends the spine and reduces the pressure on the front of the vertebral bodies thus permitting them to grow. The patient is allowed up for toilet purposes and for remedial exercises; exercises should not be very strenuous because they are only intended to preserve general muscle tone and are not actively corrective. This regime is continued until no further correction can be obtained and there is freedom from pain, usually six to twelve months, but a plaster bed should be used at night for a longer period, because there is no better way of increasing a kyphus than by lying on an ordinary bed.



FIG 55 Dorsal kyphosis The intervertebral spaces are narrow anteriorly and the bodies are beginning to fuse

## SENILE KYPHOSIS

This condition is characterized by curvature affecting the upper dorsal vertebræ and is usually associated with a greater or lesser degree of osteoarthritis of the corresponding intervertebral joints. It occurs particularly in manual workers and seldom before sixty years of age although occasionally it is seen much younger. The process starts in the intervertebral discs which undergo degenerative changes of senile type (p. 76); the discs become thinner, specially anteriorly, their resilience is reduced and the pressure on the front of the vertebral bodies is increased. The vertebræ, possibly already porotic, absorb anteriorly becoming wedge-shaped and finally the discs ossify thus fusing together the anterior borders of vertebræ (Fig. 55).

routine physical examination. The kyphus involves the middle and lower dorsal regions; the curve is smooth and is accentuated during flexion because it interrupts the even line of the rest of the back. The lumbar and cervical curves are increased in compensation (Fig. 53).

Pain tends to start rather later than deformity. It may be complained of by boys after they first begin working, hence the disease is sometimes known as "apprentice's kyphosis." During the active stage pain is felt in the region of maximum deformity; it is not severe and usually comes on towards the end of the day, or after playing games.



Fig. 54 Adolescent kyphosis in a girl aged 15 complaining [illegible]

In the absence of treatment deformity may progress until ossification is complete at about twenty-two years of age, and thereafter it is permanent. The appearance is characteristic and can be recognized at any age. Pain ceases with growth but it often recurs in later life, usually in the lumbar region where there is a compensatory lordosis.

**Dorsolumbar Kyphosis.** This deformity is associated with certain postural defects, and although it is very common in girls, it is often overlooked (p. 7). The pathology and X-ray appearances are identical with the more generally recognized form of adolescent kyphosis described above; the course also is similar but pain is usually less marked.

**X-rays.** (Figs. 53 and 54.) The principal features are irregularity in ossification of the epiphysial rings, Schmorl's nodes and wedging of the vertebræ (p. 74). There is often some narrowing of the intervertebral spaces. The differential diagnosis from tuberculosis is occasionally difficult but there is no general rarefaction of bone or abscess formation, and the outline of the bodies of the vertebræ is intact except at the angles.

## Treatment

Admission to hospital is desirable when there is pain or when the deformity is severe. A plaster bed is made in the position of maximum correction but without undue exaggeration of the lumbar curve. The

## SENILE OSTEOPOROSIS

Osteoporosis of the bodies of the vertebræ occurs in middle-aged or elderly people without necessarily being accompanied by generalized osteoporosis of the whole skeleton. The metabolic significance is not known. Not infrequently the porosis is of such remarkable degree that the vertebræ collapse either spontaneously or as the result of very minor injury. A single body, or more often two or three adjacent ones, give way anteriorly and are reduced to a fraction of their original thickness; occasionally several groups of vertebræ in different parts of the spine may collapse. The intervertebral discs remain intact, and since they are not as a rule degenerate, their elasticity causes them to bulge out into the soft bones giving the appearance of bi-convex lenses (Fig. 56).

There is seldom a history of trauma and the principle complaints are backache and increasing deformity. Extreme collapse, however, may cause pressure on the nerve roots in the intervertebral foramina and give rise to most intractible pain of root distribution; spasms of pain are brought on by any movement of the back, particularly rotation, and sleep is difficult because spasms occur as soon as the muscles relax.

In less severe cases a spinal support helps to relieve pain and protect the spine against collapse. Many patients, however, being rather frail, are unable to wear a rigid brace and at most can tolerate a strong corset which is only of limited assistance. A plaster bed is often of help in reducing pain at night, and it may prevent an increase in deformity. Severe root pain is not always controlled by opiates and can be so distressing as to demand drastic measures; a localized intrathecal injection of alcohol may be practicable but sometimes there is no alternative to division of the pain tracts in the spinal cord.

## ANKYLOSING SPONDYLITIS

(*Synonym*) Spondylitis Ankylopoietica

This common disease is characterized by ossification of the joints and ligaments of the spine. It may be allied to rheumatoid arthritis although little is known about the ætiology. The incidence is greatest during the third and fourth decades and males are affected more frequently than females. The disease occurs in a common form and in two special types but it is probable that all three types represent different reactions to the same disease process. The special types are uncommon in pure form but any of their features may be seen complicating the ordinary form.

### Pathology

Joints. The sacroiliac joints are usually the first to be affected, then the intervertebral joints are involved and sometimes the costo-vertebral joints. Some of the general features of rheumatoid arthritis are present—atrophy, infiltration and thickening of periarticular tissues, and destruction of articular cartilage—but the characteristic features are ossification of the capsular ligaments and complete obliteration of the joints which are converted into a solid bony mass (Fig. 58).

The symptoms are pain and deformity. Pain occurs during the active stage: it is often severe and usually is worse at night when it may interfere with sleep. After the active phase is complete and the vertebræ have fused, pain in the region of the kyphus disappears. There may, however, be pain in other parts of the spine due to osteoarthritis.

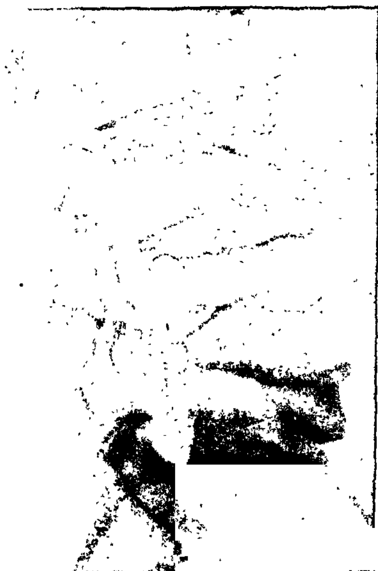


FIG 56 Senile osteoporosis with marked collapse of the lumbar vertebræ The patient had severe pain in the distribution of the fourth lumbar nerve root

Deformity affects chiefly the upper dorsal vertebræ; it is of characteristic appearance and tends to increase until fusion is complete when it becomes stationary. The deformity, if severe, is very disabling, and often the whole spine is so stiff that compensatory curves cannot be developed and it is impossible to stand upright.

There is no satisfactory treatment. A plaster bed for use at night relieves pain and reduces the rate of increase of deformity, but not all patients can accustom themselves to sleeping in one. A spinal support. if tolerated, may be worn during the day (p. 58).

Examples have been described in which the knees and elbows are affected but, as a rule, the failure of these and the smaller joints of the hands and feet to participate is striking. If the hips are allowed to ankylose in flexion, as happens if the patient is put to bed without special precautions, a dreadful deformity results; the kyphotic spine is unable to compensate for flexion of the hips and the trunk is parallel with the ground when the patient tries to stand.



FIG 58 Ankylosing spondylitis Oblique view showing ossification of the intervertebral joints

**Bechterew's Type.** The distinguishing feature of this rare form is ossification of the intervertebral discs which are converted into bone of the same consistence as the bodies of the vertebræ. The longitudinal ligaments and the intervertebral joints also ossify and the spinal column is converted into a hollow tube with the spinal cord in the centre.

## Clinical Features

PAIN. Most patients are still at work when they first come under observation; they are not ill and have little deformity, but they complain of pain. The pain starts insidiously in the lower back and progresses slowly; it is made worse by exertion and does not disappear entirely with

LIGAMENTS. The anterior and lateral longitudinal ligaments of the spine almost invariably ossify (Fig. 57), and less frequently the ligamentum flavum and interspinous ligaments are involved. The intervertebral discs do not become ossified, except in Bechterew's type. The structure of the bodies of the vertebræ remains fairly normal but there is usually sclerosis of the iliac bones adjacent to the sacroiliac joints.



FIG 57 Ankylosing spondylitis with extensive ossification of the lateral longitudinal ligaments ("bamboo spine")

MUSCLES. Wasting of the skeletal muscles is occasionally very marked and is much greater than can be attributed to disuse alone. It appears to be part of the disease and is perhaps caused by chronic inflammation of the spinal dura and degenerative changes in the posterior root ganglia and posterior columns of the cord (Strümpell).

**Strumpell-Marie Type** (*Spondyloserhysomyelique*). In this type the "root" joints are also affected. The process begins at the hip, sacroiliac and lower lumbar joints and spreads slowly up the spine; in an extreme instance the shoulders and sterno-clavicular joints are ultimately involved.



FIG. 60. Ankylosing spondylitis. There are changes in the sacroiliac joints and the ilium but the rest of the spine is radiologically normal.

## STRUCTURAL SCOLIOSIS

It is customary to divide scoliosis into two main groups, postural and structural, but the ætiology, pathology and treatment differ so widely that they cannot be regarded as the same disease. Postural scoliosis is a defect of minor importance which can be corrected by voluntary muscular effort, and it is not associated with changes in the shape of the vertebra; it is a disorder in function and as such is properly included with the other postural defects (p. 12).

Structural scoliosis is a deformity in which there is lateral curvature of the spine combined with rotation of the vertebræ; the shape of the vertebræ is altered and correction by voluntary effort is impossible. It might be expected to pass through an early stage in which it is fully correctible, but whilst this may be so in theory, in practice the transition from a mobile to a structural curve is seldom, if ever, observed.

### Ætiology

There is a formidable list of possible causes of structural scoliosis which is given in abbreviated form below. The majority of cases are due to muscular failure and this is the only type that will be discussed in detail.

A. CONGENITAL.

B. ACQUIRED.

1. *Diseases of Bone :*
   (*a*) Rickets.
   (*b*) Tuberculosis and other destructive diseases.
2. *Compensatory to obliquity of the Pelvis :*
   (*a*) Real or apparent shortening of one leg.
   (*b*) Deformity of the hip.
3. *Compensatory to Torticollis.*
4. *Muscular Failure.*
   (*a*) Anterior poliomyelitis.
   (*b*) Of unknown origin (idiopathic).

rest. Not infrequently the pain radiates into the buttocks and thighs, and sometimes there is girdle pain of abdominal or thoracic distribution. Occasionally it starts in the dorsal or cervical spine.

STIFFNESS usually begins in the lumbar spine, and to start with it is due to muscle spasm. Later, when there is bony ankylosis, the spine becomes rigid.

DEFORMITY, when present, is characteristic; the dorsal curve is increased, the lumbar curve is obliterated and the trunk is bent slightly forwards at the hips (Fig. 59). In this position it is hard to balance without the aid of sticks and it may be impossible to extend the neck sufficiently to look ahead.



FIG 59
Ankylosing spondylitis

ACUTE ONSET. Occasionally the onset is acute and accompanied by fever. Weakness and wasting of the skeletal muscles develop rapidly and may be so severe, and the patient is reduced to such a state of inanation, that his life is threatened.

**X-rays** (Figs. 57, 58 and 60). The first changes are usually to be seen in the sacroiliac joints. The iliac bones adjacent to the joints show areas of rarefaction and of condensation, and the joint spaces become irregular and are gradually obliterated. Ossification in longitudinal ligaments is more easily seen in lateral than in antero-posterior views, but in time all the paravertebræ ligaments are ossified. The intervertebral joints are gradually obliterated, commencing as a rule in the lumbar region and spreading gradually upwards. The intervertebral discs are involved only in Bechterew's type, and in the other varieties the remarkable way in which the disc spaces keep their usual size is one of the diagnostic features. On the other hand the symphysis pubis is liable to be obliterated in all types of the disease.

## Treatment

Modern developments in radiotherapeutic technique have transformed the prognosis, and although inadequate dosage is next to useless, with proper management it is possible to arrest progress and often to restore some movement to stiffening joints. Bony ankylosis cannot, of course, be affected. Active exercises and postural re-education are commenced at once and regular examination should be continued over a period of years. There should be no increase in deformity from the time medical advice is first sought.

If there is an acute illness, the patient is nursed in a plaster bed. Pyrotherapy assists in arresting this phase and radiotherapy is begun as soon as the general condition permits.

metry of the pelvis is very occasionally severe enough to cause compensatory scoliosis, but it must be distinguished from the more usual case in which pelvic asymmetry is the result of scoliosis, not the cause.

Severe compensatory scoliosis present from an early age causes minor structural changes in the vertebræ but the curve always remains partly correctible. It is, for example, corrected by sitting because the pelvis is then level and there is no longer any need for compensation ; the force causing the scoliosis only acts part of the time, i.e. when standing or walking, and therefore there is less tendency for the deformity to become fixed, and it does not become progressively worse.



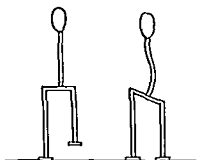


FIG 62 A girl of 16 with 2½ inches of shortening of the right lower limb

TREATMENT is unnecessary unless the difference in the length of the legs is more than a third of an inch, indeed it is unwise to tell the patient when this amount is discovered during routine examination. When the difference is half an inch or more the heels of the shoes are altered, one heel being raised and the other lowered by half the required correction. Full correction is not necessary ; thus with a disparity of one inch it is sufficient to raise one heel a quarter of an inch and lower the other an equal amount. The sole need not be raised unless the heel has been lifted at least one inch. With some patients it may be preferable to lengthen one leg or shorten the other by operation.

**Torticollis.** Upper dorsal scoliosis associated with untreated sterno-mastoid torticollis should never be allowed to develop, but severe deformities are still seen occasionally.

**Congenital Scoliosis.** There is faulty ossification of one or more vertebræ causing gross deformity. The salient feature in the usual type is failure of development of one half of the body (*hemivertebræ*), but there are usually other defects as well, including irregularity in the arrangement of the ribs. The picture is very complex when a number of defects occurs simultaneously (Fig. 61). The deformity of necessity increases with growth of the hemivertebræ and may become extreme.

TREATMENT is of little avail. Spinal fusion by means of a graft placed on the convex side of the curve, if carried out at an early age, may restrict growth of that side to some extent.



FIG 61 Multiple congenital deformities of the vertebræ and ribs

**Diseases of Bone.** Rickets is now a rare cause of scoliosis in western countries although once it was common. Tuberculosis, which is the only common destructive disease of the spine in children, causes kyphosis more often than lateral curvature, and in the few instances in which there is scoliosis the element of rotation is absent.

**Compensatory Scoliosis.** When the pelvis is oblique, the spine is curved in the endeavour to assume an erect position (Fig. 62). The common cause of obliquity of the pelvis is real or apparent shortening of one leg; shortening up to half an inch has little visible effect on the spine, but more than that produces a distinct compensatory curve. Congenital asym-




FIG. 63 "Idiopathic" left dorsal scoliosis.

*Left* The amount of curvature is often measured by joining the centre of the body of the vertebra at the apex of the curve with the centres of the bodies at each end.

*Right* Cobb's method of measurement is to determine the angle between the perpendiculars drawn from the top and bottom of the vertebræ at the extremities of the curve.

**Muscular Failure.** This is the usual cause of severe scoliosis.

ANTERIOR POLIOMYELITIS accounts for a fair percentage of cases which varies from country to country according to the incidence of this infection. Scoliosis occurs when there is unilateral paralysis, or greater paralysis of the muscles on one side of the spine than the other. The curve is concave towards the stronger side, and it is rapidly progressive during the growth period It is greatest when the small rotator muscles are involved. Paralysis of the abdominal muscles may cause lateral curvature even when the spinal muscles are unaffected.

"IDIOPATHIC." This is the commonest type of severe scoliosis but next to nothing is known about the ætiology. It has been suggested that the primary defect may be lack of proper co-ordination of the small rotator muscles controlling the movements of individual vertebræ.

## Nomenclature

The curves are named after the region affected and the direction of the convexity. A curve in the dorsal region with its convexity to the right is called a right dorsal scoliosis. A compound curve convex to the right in the dorsal region and to the left in the lumbar region is called a right dorsal, left lumbar scoliosis.

The amount of curvature is measured radiographically by drawing two lines from the centre of the body of the vertebra at the apex of the curve to the centres of the bodies at each end (Fig. 63). The angle between these lines subtracted from 180° is the amount of deviation from the straight. It varies from 10° to 90°, the majority being between 20° and 40°. The angle is usually smaller when the patient is sitting than when he is standing, and smaller still when lying.

## Mechanics

Much ingenuity has been devoted to explaining the exact mode of development of lateral curvature, but no theory is entirely satisfactory and none is universally accepted. For practical purposes the spine can be regarded as "buckling" in a region in which there is a disorder in muscular function. If the disorder is limited to a small area in the dorsal or lumbar region, there is a dorsal or a lumbar scoliosis with a smaller, secondary, compensatory curve below or above the primary curve. The more severe compound curves occur when muscle failure is extensive and involves both dorsal and lumbar regions.

Lateral deviation is always accompanied by rotation; one cannot occur without the other, but their relative severity varies and sometimes one and sometimes the other predominates. When a curved rod is given a second curve in a different plane, it necessarily twists in its longitudinal axis. The spine is such a rod curved in the antero-posterior plane, and when a lateral curve is superimposed, torsion stresses are set up and the vertebræ rotate. *The rotation is in that direction which moves the bodies of the vertebræ towards the convexity of the curve and the spinous processes towards the concavity,* i.e. the bodies are displaced further from



Fig 64 Scoliosis following anterior poliomyelitis There is gross rotation of the vertebræ causing a "razor back" deformity



Fig 65 "Idiopathic" left lumbar scoliosis



Fig 66 "Idiopathic" left dorsal right lumbar scoliosis



Fig 67 "Idiopathic" scoliosis treated by remedial exercises with marked improvement in posture Note the apparent

the mid-line than the spines. In scoliosis caused by failure of the small rotator muscles, there is likely to be a greater degree of rotation than is warranted by the severity of the lateral curve. A kyphotic element is often superimposed on the lateral curve, particularly when the primary curve is in the dorsal region.

Changes in the shape of the vertebræ take place whilst they are still growing in response to alterations in pressure and in adaptation to the abnormal posture. The bodies are compressed on one side, the exact shape varying with the position in the curve; that at the apex is wedged but the others tend to be lozenge shaped (Fig. 63). The pedicles, articular processes and transverse processes are mis-shapen and the neural canal becomes triangular in cross section. The thorax is often seriously distorted in dorsal scoliosis but the extent depends on the degree of rotation. The ribs rotate with the vertebræ and project forwards on the side of the concavity, and backwards on the side of the convexity. Sometimes the posterior angles of the ribs are bent so sharply that the resulting deformity is well described as "razor back" (Fig. 64).

## Clinical Features

"Idiopathic" scoliosis commences during childhood, often in the preadolescent period. It may be discovered at routine school examination, or the child is brought to the doctor because the parents or dressmaker have noticed that one hip sticks out, or that one shoulder is high (Fig. 65). The deformity is obvious on clinical examination provided it is carried out with the child completely undressed. It is distinguished from postural scoliosis by the fixity of the curve which is not corrected by standing on one leg, by sitting, or by flexing the spine. X-rays show distortion of the vertebræ at a very early stage.

There is no pain or disability during early life although pain is common in adults. The muscles of the back are working at so great a mechanical disadvantage that, towards middle age, they can no longer stand up to the strain and very distressing backache may result (p. 50). Osteoarthritic changes are common. Pain is greatest at the levels where the curves change direction, that is at the apex, at the transition of a compound curve from one side to the other, and at the transition from curved to straight parts of the spine.

Interference with general function is not great, even with moderately severe scoliosis, provided suppleness is maintained. The girl illustrated in Fig. 66 is an excellent tennis player, and there are several examples of athletes and ballet dancers with some fixed deformity. Very severe deformities may cause some mechanical interference with the thoracic and abdominal viscera. Paraplegia, partial or complete, is an occasional complication. It is apparently due to compression of the cord in the distorted spinal canal, and a sub-arachnoid block can often be demonstrated by myelography. Laminectomy, if performed early, is usually followed by considerable improvement.

There is seldom difficulty in determining the ætiology if the possibilities are borne in mind, and if examination includes such points as the length of

**Corrective Plaster Jackets.** These are used to relieve the bodies of the vertebræ from pressure tending to deform them. They have been in use for very many years and *yet there is no unanimity of opinion* as the best method of application, a good indication of the uncertainty of the results.

THE ABBOTT JACKET takes advantage of the observation that the respiratory excursion of the flattened aspects of the chest, which *normally* is negligible, is increased when the projecting aspects are fixed. The jacket is applied in flexion using corrective bands to exert pressure over the projecting ribs. Large windows are cut in the plaster over the flat parts of the chest to permit respiratory movements during breathing exercises.

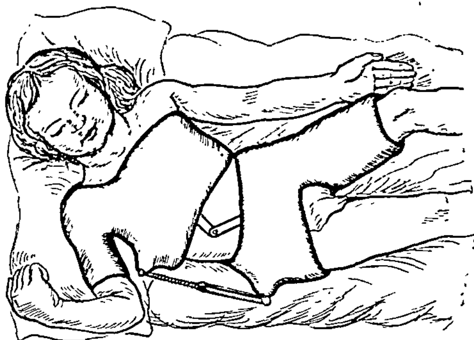


FIG 68 Risser jacket

THE RISSER JACKET promises to give the most favourable results. A plaster jacket is applied during head extension, and usually including the *thigh on the convex side, and the neck and one arm.* It is split circumferentially at the level of the apex of the curve and hinges are fixed in the sagittal plane a little to the concave side of the mid-line. A turnbuckle is fixed in the axillary line on the concave side and unscrewed over a period of days thus forcibly bending the spine round the apex of the curve. The eccentric placing of the hinges causes some elongation of the plaster and allows for the increase in length that occurs when the spine is straightened.

**Spinal Supports.** Spinal braces of the types described on p. 58, or celluloid or plastic jackets made to the shape of a plaster cast, are often used for a period after corrective plasters are finished with. They are of special value when the curvature is of paralytic origin, and they may have to be worn permanently. A plastic jacket is tolerated as a permanent fitting by many patients, but a spinal brace is most irksome and usually is discarded sooner or later.

the legs, the movements of the hips, and the power of the abdominal muscles. The chief problem is to differentiate "idiopathic" scoliosis from that due to anterior poliomyelitis with residual paralysis restricted to the smaller spinal muscles.

**Prognosis.** Acquired scoliosis due to muscle failure, when untreated, progresses throughout the period of vertebral growth. The outlook is particularly bad in children with anterior poliomyelitis affecting the rotator muscles. With "idiopathic" scoliosis, it is difficult, if not impossible, to give a prognosis when a patient is seen for the first time. Sometimes treatment seems to improve muscular co-ordination and prevent the deformity increasing, but it progresses in a most disheartening way in spite of treatment. Lambrinudi compared the condition with pes cavus caused by intrinsic muscle failure and aptly described the progressive type as "malignant."

## Treatment

Treatment is necessarily a prolonged and specialized business. The earlier it is started, the greater the chance of success, but it must be continued until growth is complete. There are three lines of attack :—

(1) *Remedial exercises.*
(2) *Relief of pressure by mechanical aids.*
(3) *Spinal fusion.*

**Remedial Exercises.** Exercises play a part in all phases of treatment. They may be used as the only method of treatment when the deformity is slight, and for as long as they prevent it increasing ; breathing exercises are given whilst in a corrective plaster ; mobilizing exercises and postural re-education are used between plasters, when plaster treatment is finished, and after spinal fusion.

Exercises have three aims :—

(*a*) To restore mobility.
(*b*) To restore muscle power and balance.
(*c*) To provide the best compensatory posture.

There are many systems of exercises each of which is claimed by its exponents to give the best results. The essential features are the localization of movements to particular regions of the spine, and the development of mobility and poise. Unilateral exercises designed to strengthen the muscles on the convex side of the curve were once popular, but it is now realized that mobility rather than correction is the objective and at many clinics they have been abandoned in favour of bilateral exercises.

In assessing the results of treatment by remedial exercises, it is important to distinguish between a real alteration in curvature and clinical improvement due to the adoption of the best compensatory posture. There is little evidence that any real decrease in deformity as measured in radiographs can be brought about by exercises alone. The patient illustrated in Fig. 67, who was treated by Miss Celia Sparger, achieved a remarkable improvement in general deportment, but there was no alteration in the bony deformity.

myelocele. There is *often an associated minor cutaneous defect* such as a dimple, tuft of hair or lipoma which requires cosmetic treatment.

**2. Meningocele.** The meninges protrude through a defect in the neural arch (or cranium). The protrusion contains only cerebro-spinal fluid, and the spinal cord and nerve roots are in their normal position. It is usually in the mid-line of the back and is covered with normal skin, except sometimes over the apex. It is translucent, it transmits an impulse on crying or coughing, and it can be reduced in size by pressure. Operative removal may be attempted and is often successful (Fig. 70B).

**3. Meningo-myelocele.** This projects backwards like a meningocele but it is usually more fusiform in shape. The spinal cord or cauda equina

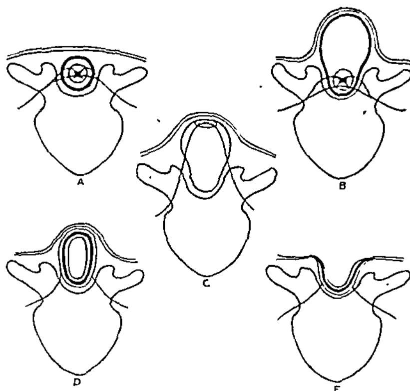



FIG 70 Spina bifida
A Occulta B Meningocele C Meningo-myelocele
D Syringo-myelocele E Myelocele

are adherent to the posterior surface of the sac and the nerve roots perforate the sac on their way to the intervertebral foramina. This type is almost always accompanied by organic symptoms which vary *in severity* from slight weakness of the lower extremities or sphincters to complete paraplegia. Operative interference is seldom successful (Fig. 70c).

**4. Syringo-myelocele.** Tl
distended and often the me
dilated cord in contact with
plegic and seldom survive for long; operation is likely to hasten death (*Fig. 70D*).

**5. Myelocele.** The primitive medullary groove fails to close and the central canal opens dorsally on to the surface of the body. The condition is not compatible with life (Fig. 70E).

**Spinal Fusion.** Operative fusion of the vertebræ is desirable in selected patients and may be carried out by any of the methods previously described (p. 59). The operation is conveniently performed through a window cut for the purpose in a plaster jacket. The points to be considered when making a decision about operation are the ætiology, the severity of the curve, the compensatory posture, the tendency to relapse and the age of the patient. A patient with moderate curvature and good correction at fifteen or sixteen years of age will probably maintain the posture without fusion. A more severe curvature in a younger patient that has been partially corrected in a Risser jacket is likely to relapse unless fused. Fusion is often required in anterior poliomyelitis and should be performed early.



FIG 69 Spina bifida occulta The laminæ of the third, fourth and fifth lumbar vertebræ have failed to fuse There were no symptoms attributable to the defect

## SPINA BIFIDA

Spina bifida is a condition in which there is imperfect development of the neural arch, meninges, or spinal cord. A defect of the meninges or cord is always accompanied by failure of the laminæ to fuse, but failure of fusion without any other defect (spina bifida occulta) is one of the commonest skeletal anomalies. There are five degrees of spina bifida (Fig. 69 and 70).

**1. Spina Bifida Occulta.** Some degree of failure of fusion of the neural arch is present in about 10 per cent of all spines, usually in the lower part. The condition is nearly always symptomless and then no treatment is required. Sometimes, however, there are associated troubles such as pes cavus, and occasionally enuresis, which may be attributable to a fibro-fatty pad pressing on the cauda equina, or to a mild degree of meningo-





FIG. 71 Spondylolysis There is a defect in ossification of the pars inter-articularis of the *fourth* lumbar vertebra the "terrier" has a *collar on*





FIG 72 Spondylolistheses The fourth lumbar vertebra is displaced slightly forwards. the "terrier" is decapitated

## SPONDYLOLISTHESIS

The vertebræ ossify from three main centres, one for the body and one for each half of the neural arch. Failure of fusion between the neural arch and the body is known as *spondylolisis* and is a common anomaly estimated to occur in about 3-4 per cent of the population. The defect is usually between the articular processes (pars inter-articularis) and often bilateral (Fig. 71); the affected vertebra has no bony attachment to the vertebra below and is joined to it only by soft tissues. In *spondylolisthesis* the affected vertebra divides at the points of defective union and slides forwards together with the whole spinal column above it; only the inferior articular processes remain in situ (Fig. 72). It is probable that the shift commences, at any rate in most patients, before, during, or soon after birth. The deformity may increase for a time, but adaptive changes in the shape of the vertebral bodies take place only during childhood and this indicates that there is not usually much alteration later in life.

Spondylolisis and very minor degrees of spondylolisthesis are readily demonstrated in oblique X-rays. These are easier to interpret when the neural arch is visualized as a picture of a "terrier." I do not know who was originally responsible for this ingenious idea, but it was pointed out to me by Watson-Jones to whom I am indebted for the X-ray in Fig. 72. The head of the "terrier" is formed by the pedicle and transverse process, the ears by the superior articular process, the neck by the pars inter-articularis, the body by lamina, and the front and back legs by the two inferior articular processes. The normal appearance is shown in the fourth lumbar vertebra in Fig. 72. When the "terrier" has a collar on, as in the fourth lumbar in Fig. 71, there is defective union at the pars inter-articularis without displacement (spondylolisis); when the "terrier" is decapitated, there is spondylolisthesis. A very small amount of displacement is visible in oblique views; no abnormality can be detected in the antero-posterior and lateral views of the patient illustrated in Fig. 72 although there is an appreciable displacement.

Spondylolisthesis affects men with about twice the frequency of women. The defective vertebra in some 90 per cent of cases is the fifth lumbar and this vertebra is displaced forwards on the sacrum. The fourth lumbar accounts for most of the remaining 10 per cent, but occasionally the other lumbar vertebræ, and very rarely the dorsal or cervical vertebræ, are involved. The amount of displacement varies from a fraction of an inch to a complete dislocation in which the posterior border of the body of the upper vertebra slips over the anterior border of the vertebra below. A usual displacement is between a quarter and a half of the breadth of the body (Fig. 74).

There is post-mortem evidence that spondylolisthesis is occasionally caused by major hyperextension injuries. The vertebra is rotated backwards with the inferior intervertebral articulations as fulcrum until further movement is prevented by the spinous process abutting on its neighbour below; continued violence then tears the intervertebral disc and fractures

merges into that of the lower borders of the transverse processes making a shape like a bow which the French describe as resembling a gendarme's helmet. The defect in the neural arch can sometimes be seen in lateral films but it is better demonstrated in oblique views.

## Treatment

Relief from backache, whether the displacement is trivial or extensive in amount, is often given by remedial exercises to strengthen the erector spinæ. Sometimes manipulation is helpful and it is well worth a trial, particularly when there are secondary symptoms in other parts of the back. A lumbosacral corset or spinal brace may be used when it is necessary to restrict painful movement (p. 58).



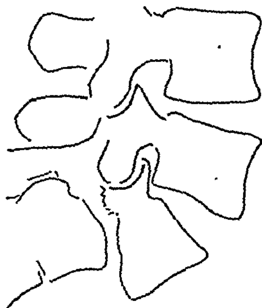


FIG 74 Spondylolisthesis The fifth lumbar vertebra is displaced forwards on the sacrum about half its depth Note the alteration in shape of the bones suggesting that the defect has been present since early in life

Spinal fusion is indicated for relief of pain after conservative measures have failed, and sometimes for economic reasons in heavy workers. It is also desirable when there is severe sciatic pain, but the extradural portions of the nerve roots should be explored at the same time. Fusion may be performed by any of the standard methods described on p. 59, or by an anterior graft. The latter, which is only possible when there is gross displacement, was first described by Burns and has not received the attention it deserves. The fifth lumbar body is exposed by a trans-peritoneal approach and a tibial graft driven through it into the sacrum; the operation is difficult only when the bifurcation of the vena cava is at a lower level than usual and then great care is necessary.

Reduction may be attempted when the displacement is caused by, or increased by, recent trauma. Weight traction is applied to both legs and a sling placed round the pelvis to lift it forwards. If this is not successful within a few days, it is not worth persisting longer. Successful reduction should be followed by spinal fusion.

the neural arch at its weakest spot. Spondylolisthesis diagnosed after an accident is not necessarily caused by it; more often than not there is a pre-existing painless displacement and the accident precipitates the onset of symptoms.

## Clinical Features

Spondylolisis, as far as is known, is a symptomless condition. The amount of displacement that is necessary to produce symptoms is at present uncertain but it is probable that very little may cause sufficient tension on the soft tissues attached to the vertebræ to be painful. Spondylolisis and minor degrees of spondylolisthesis may well prove to be a commoner cause of chronic low back pain than is at present appreciated.


Fig 73 Spondylolisthesis

When there is gross slipping the symptoms sometimes begin during childhood, but often the onset is delayed until early adult life. Patients come under observation complaining of backache. The pain is seldom severe and does not interfere with games, but it may prevent heavy manual labour. It is usually worse on getting up from rest, and there may be a definite sensation of something moving in the spine when twisting. The pain is often intermittent and associated with particular movements; sometimes it is referred over the distribution of the sciatic nerve, and although objective motor or sensory changes are unusual, a typical sciatic syndrome is occasionally present.

The shape of the back is characteristic (Fig. 73). The sacral region looks unduly long, and *immediately above the fifth lumbar spine is a* sharp depression which may be so pronounced as to be almost like a shelf. The depression becomes more marked if the patient, when lying prone, lifts the shoulders from the couch. The lumbar region is short and the ribs and iliac crests are closer together than in normal people.

Spondylolisthesis was first described by obstetricians and at one time was of interest only as a complication of labour. Great displacement may well narrow the pelvic brim sufficiently to prevent the passage of a baby, but many women with a considerable amount of displacement have had a normal labour.

**X-rays.** Lateral radiographs show the displacement clearly only when there is gross displacement (Fig. 74), but minor degrees can sometimes be detected by drawing a line perpendicular to the upper surface of the sacrum at its anterior angle; this line normally touches the antero-inferior angle of the fifth lumbar vertebra. In antero-posterior views, the line of the anterior border of the body of the fifth lumbar vertebra

is that the condition is akin to Völkmann's contracture and is caused by interference with the arterial blood supply (p. 327). It is possible that a very few cases are due to an amyoplasia similar to that in arthrogryphosis.

## Symptoms

A "sternomastoid tumour" is sometimes present, but not always, at or very soon after birth. It consists of fibrous tissue and forms a hard, firm lump in the substance of the muscle; it gradually decreases in size and eventually disappears.

Restriction of movement of the neck may be noticed by an observant mother at the age of a few months. Deformity is not usually visible until about a year and then it slowly increases because the sternomastoid fails to grow at relatively the same speed as the cervical spine. When the characteristic appearance has developed, the contracted muscle stands out like a cord and the head is pulled to one side and tilted so that the face looks upwards and to the opposite side (Fig. 75). If untreated, the deformity may become very severe, and by the time adult life is reached there is a compensatory upper dorsal scoliosis and elevation of the shoulder which make the general appearance most unsightly.

Facial asymmetry develops at the same time as deformity of the neck. The half of the face on the side of the affected muscle becomes smaller and shorter, and the eye lower than the other. Asymmetry is less noticeable when the head is on one side, and more obvious when the head is straight and the rest of the body covered up.

Double torticollis in which both sternomastoids are affected has occasionally been reported. The neck, as viewed from the front, is straight, but it appears short and the face is tilted upwards.

## Differential Diagnosis

Other possible causes of wry-neck include :—

*Habit*
*Bony abnormalities of the cervical vertebræ.*
*Tuberculosis of the cervical vertebræ.*
*Ocular torticollis.*
*Paralysis of the sternomastoid and other cervical muscles.*
*Cicatricial contraction.*
*Reflex Irritation. Inflammation of cervical lymph glands.*
*otitis media.*
*parotitis.*
*Spasmodic torticollis.*

Some children form the habit of holding their heads to one side without discoverable cause: the sternomastoid are normal, there is a full range of active and passive movements, and no ocular defect. The habit is readily corrected by re-educational methods.

Developmental defects and diseases of bone are excluded by X-rays. Ocular torticollis may occur in children or adults with good binocular vision but with overaction of one or more of the ocular muscles that elevate or

## TORTICOLLIS

It is customary for historical reasons to classify together the different varieties of wry-neck although this may be the single symptom that a number of entirely different diseases happen to have in common. The term "torticollis" is now identified with the commonest of them, "*congenital*" *sternomastoid torticollis*, a condition occurring in infants in which the primary defect is in the sternomastoid muscle (or its blood supply). It would be advantageous if the other causes of wry-neck were associated only when discussing the differential diagnosis.



Fig 75 Right torticollis

In "congenital" sternomastoid torticollis, the sternomastoid muscle fails to increase normally in length during early growth. Histological examination of the muscle shows that it contains more interstitial fibrous tissue than usual, and also fibrous patches resembling old scars. If the deformity is left uncorrected for some years, the other soft tissues in the neck are shortened and the vertebræ become altered in shape in adaptation to the abnormal posture.

There is doubt about the ætiology. At one time it was believed that the trouble was caused by injury during birth; the small tumour in the muscle that is often present soon after birth was thought to be a hæmatoma, and it was assumed that a few muscle fibres were torn. Later it was shown that acute flexion of the neck during delivery could obstruct the venous return and it was suggested that the muscle fibres suffered damage from anoxia. These theories are no longer accepted and the present view

feels like when the head is straight—he has to condition a new reflex. He is placed in front of a mirror, his eyes are covered, and he is told to put his head straight; then his eyes are uncovered and he can see the result. This is repeated until the proper postural sense is acquired. In addition, exercises and passive movements are given to prevent excessive contraction of the tenotomy scar and a return of deformity.

## CONGENITAL ELEVATION OF THE SCAPULA

### (*Synonym*) Sprengel's Deformity

This is an uncommon congenital deformity in which the shoulder girdle, which develops as a cervical appendage, fails to descend properly during early fœtal life. The scapula is higher than its fellow and usually rotated so that its lower angle is nearer the vertebral column (Fig. 76). The scapula may also be smaller than normal and the upper part hooked forwards round the upper border of the thorax. The condition is occasionally bilateral.

In most instances there are other congenital defects and deformities of the ribs, vertebræ and muscles ranging in severity from spina bifida occulta to congenital wedge vertebræ and amyoplasia. Often there is a fibrous band, or a cartilaginous or bony bar, joining the scapula to the spinal column, usually the fourth to seventh cervical spinous processes, and this greatly restricts movement of the shoulder girdle.



Fig. 76

### Treatment

When the deformity is only of moderate severity, some benefit may be derived during infancy from passively stretching the muscles supporting the shoulder girdle, and at a later age from mobilizing exercises.

Operation seldom gives a really good result, but even with severe deformities it may improve the general appearance and increase the mobility of the arm. A wide exposure is made and the muscles are detached from both the upper and vertebral borders of the scapula, and from the spinous processes; an abnormal bar of bone or band of fibrous tissue is removed and also, if it is hooked forwards, the upper part of the scapula itself. It may then be possible to pull the scapula lower down the thorax, but there is a strong tendency, even if it is anchored to one of the ribs, for it to ride up again later. When there are multiple congenital deformities, particularly defects of the vertebræ, scoliosis may be the major therapeutic problem and the position of the scapula is ignored.

depress the eye. An abnormal position of the head is taken up in order to make the visual axes parallel and obviate the diplopia which would otherwise result. The usual muscle to be affected in children is the inferior oblique which both elevates the eye and rotates it externally. The elevating action is mechanically greatest when the eye is adducted, and absent when it is abducted. Therefore, when there is overaction of one inferior oblique, the head is habitually held turned to the opposite side and the eyes to the same side so as to keep the affected eye abducted; there may also be a variable amount of tilting of the head (Goldsmith).

Spasmodic torticollis is a functional nervous disorder in which clonic contraction of the muscles of the neck, including the sternomastoid, is but one manifestation of an hysterical condition. Its treatment is entirely outside the province of surgery.

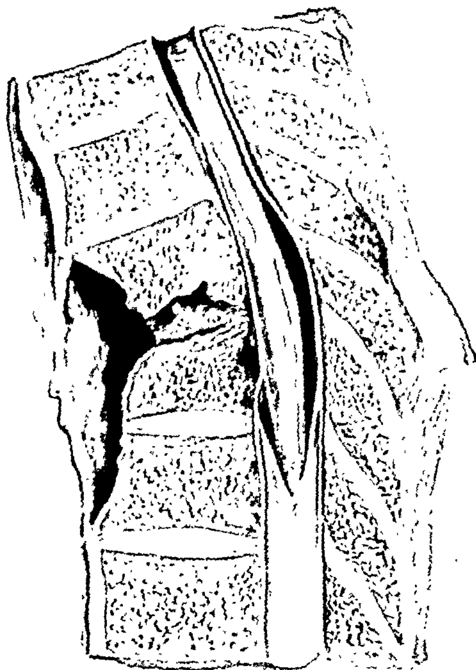
## Treatment

**Conservative.** In infants, at the stage when there is limitation of movement of the neck but little or no deformity, it is often possible to restore the full range of movements by repeated passive manipulation. This should be carried out by a physiotherapist who is familiar with the normal range, and not by the child's mother who is likely to be frightened of causing damage. Full correction is usually obtained in a few weeks and in most patients developement then proceeds normally; the child should, however, be kept under regular observation for at least a year because occasionally there is a relapse and tenotomy is necessary. When there is extensive degeneration of the muscle, or if there is congenital amyoplasia, conservative treatment is without effect.

**Operative.** Division of the sternomastoid is necessary in older children and it should be carried out as early as possible before other structures in the neck have contracted, and before facial asymmetry is marked. Asymmetry is more obvious for a time after operation, but provided the neck is straightened whilst the child is still young, the face gradually returns to normal over a period of years; it is unlikely to recover completely in children over eight or ten years of age at the time of operation.

The sternomastoid can be divided at open operation or by subcutaneous tenotomy just above the clavicle; the latter is quite satisfactory in young children. In older children the deep cervical fascia may be contracted and require division also; this is conveniently managed, and with an inconspicuous scar, through a transverse incision in one of the creases of the neck. A severe contraction may require division of both ends of the sternomastoid; the upper end is approached through a transverse incision just below the mastoid process. It is not advisable to operate on young adults if there are adaptive changes in the shape of the vertebræ.

Proper after-treatment is essential. Some surgeons attempt to fix the head straight for several weeks by a collar of one sort or another, but no apparatus does this efficiently. If the child is old enough to co-operate, it is better to rely on educative methods. The child has to learn what it



Tuberculous Disease of the Spine
*(By courtesy of Prof. H. J. Seddon.)*

*To face page 104*

## TUBERCULOSIS OF THE SPINE

Tuberculous disease of the spine, first described in English by Percival Pott in 1779, is essentially a disease of childhood. *About 70 per cent of* cases start between the ages of two and five years, and 15 per cent between five and ten years; the remaining 15 per cent are distributed fairly evenly through the rest of life. The spine is the commonest site of bone and joint tuberculosis and accounts for about half the total. The incidence is greatest in the lower dorsal region, and then in the lumbar, upper dorsal and cervical regions in that order of frequency. The sexes are affected equally.

### Pathology

The initial focus of infection is most commonly in the body of a vertebra close to one of the hyaline cartilage plates, and only occasionally elsewhere, e.g. the intervertebral joints or spinous processes. The area of *infection enlarges until several adjacent* vertebræ are involved; sometimes there is dissemination to a distant vertebra via a paravertebral abscess (Plate I).



FIG. 77 Paravertebral abscess fusiform type

The bodies of the affected vertebræ are gradually destroyed until ultimately they collapse. The neural arch and intervertebral joints usually remain intact and therefore the bones do not telescope, but angulate sharply forwards. The amount of angulation depends on the extent of destruction and the number of vertebræ involved (Fig. 80).

The intervertebral discs usually disintegrate, probably as the result of their blood supply being cut off when the adjoining vertebræ are destroyed, and not because of direct invasion by the tuberculous process to which they are very resistant.

Repair is by fibrous replacement of the tuberculous tissue and this is more readily accomplished after collapse, which reduces the total area concerned, than if collapse is prevented during treatment. In the course of time the fibrous tissue may be converted into bone; ossification starts peripherally and spreads inwards, but is exceedingly slow. Abscesses gradually dry up when the disease becomes quiescent leaving a mass of inspissated material which may also partly calcify.

**Abscess Formation.** This is so usual an event that it can hardly be

called a complication. The abscess is a thick walled structure lined with tuberculous granulation tissue and containing a quantity of thickish matter which consists of serum, caseous material, degenerate tissues and blood cells. The volume produced may be very large and as much as a pint a week has been aspirated from a single abscess. Some abscesses are small and localized but others track far in a direction determined by the fascial planes. The fascia may be perforated when the abscess is under tension by reason of the small space available for it, or the large volume of fluid.

The typical lumbar abscess enters the sheath of the psoas muscle at its attachment to the vertebræ and comes to the surface below the inguinal ligament, but occasionally it enters the femoral canal and appears much lower in the leg. A lumbar abscess may also track backwards with the lumbar vessels passing between the erector spinæ to present in the back near the mid-line.

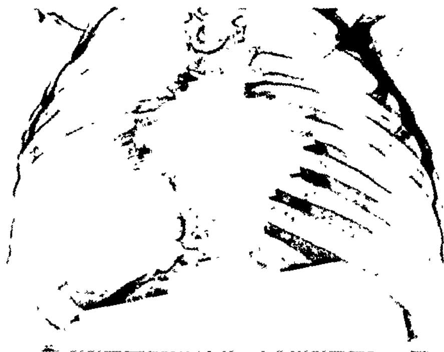


Fig 78 Paravertebral abscess, "bird's nest" type

Dorsal abscesses are confined by the longitudinal ligaments which give less freedom for expansion. The typical abscess produces a fusiform, paravertebral swelling (Fig. 77), but it may burst into the mediastinum where it is walled off to form the "bird's nest" type (Fig. 78). Occasionally a dorsal abscess follows the vessels along an intercostal space and presents by the sternum. A cervical abscess is confined by the prevertebral fascia and may burst into the pharynx or track laterally.

The "aneurism phenomenon" is an interesting feature sometimes seen in connection with an abscess. The pulsation of the aorta is transmitted by the fluid abscess to the spinal column. The intervertebral discs and epiphysial rings are dense enough to remain unaffected, but the intermittent pressure causes absorption of the softer bone between the rings (Fig. 80).

(Fig. 79). Extreme deformity compresses the thoracic and lumbar viscera and may distort the main blood vessels causing cardiac hypertrophy.

**Abscess.** *The usual sites for an abscess to present are the groin* and the loin, and sometimes it appears very early. The abscess forms a large, fluctuating swelling which, in the groin, may be mistaken for a hernia.

**Diagnosis.** In children diagnosis can often be made on clinical grounds alone—*deformity and muscle spasm are nearly sufficient evidence*—but radiological confirmation must always be sought. Indeed, radiology is a routine procedure for every patient of whatever age who has symptoms which can possibly be referable to the back. The early changes in tuberculosis are irregularity in outline of a vertebral body, decalcification, diminution in depth of the body and narrowing of the intervertebral space (Fig. 81). Abscess shadows may be visible very early; the psoas sheath normally is clearly outlined and alteration in its shape is of great diagnostic importance. At a later stage X-rays show gross destruction of bone, the ... the vertebral bodies collapse, and sometimes

In adults it may be very difficult to distinguish tuberculosis from a new growth, usually a secondary deposit, because of the variation in the X-ray appearance from patient to patient. At a younger age, adolescent kyphosis may closely simulate tuberculosis but the outline of the bodies of the vertebræ is intact except at the angles, and there is no general rarefaction or abscess formation (Fig. 54, p. 78).

## Paraplegia

This grave complication occurs in about 11 per cent of all patients with spinal caries (Butler), and of these, 85 per cent are associated with disease of the dorsal spine; the condition is practically unknown in the low lumbar region. In adults, but rarely in children, paraplegia may be the first sign of spinal tuberculosis.

Butler and Seddon have divided paraplegia into three main types:—

**Type 1** (40 per cent). *Paraplegia with early active disease but recovering.* The onset of paraplegia is usually within the first two years of disease, often at about the time of its greatest development. It progresses rapidly to the stage of paraplegia in extension, not usually further, then remains stationary for a period, and finally recovers. It is due, in the main, to inter... n tissu... s or by ... e bar to invasion of the inner meninges and spinal cord by the disease.

Treatment is by fixation in hyperextension (even though paraplegia sometimes develops in spite of careful treatment in extension). Spontaneous recovery is the rule, but if the paraplegia continues to increase, or fails to start recovering after some months, operation is advisable. The abscess is then evacuated by a postero-lateral approach which involves resection of one or two transverse processes and the posterior ends of the corresponding ribs (*costo-transversectomy*).

## Clinical Features

Tuberculosis of the spine is an insidious disease which may fail to attract attention until a fall or minor injury causes pain. The first symptoms are easily overlooked: there may be no more than an unwillingness to play outdoor games or to romp, or undue fatigue, or a slight limp when tired. The characteristic signs and symptoms develop later.

**Pain.** There is seldom severe pain, even with advanced disease, and as a rule the patient is apprehensive rather than in pain. Sometimes there is an ache in the back, sometimes the pain is referred segmentally to the ear, stomach, etc. Movements, specially twisting and jarring the back, make the pain worse, and there is a tendency to avoid certain actions such as jumping, or riding in a bus.

**Limp.** The gait is affected when the spine is stiff because of muscle spasm, or when there is a psoas abscess, and therefore limp is common in lumbar disease and may be the first sign to be noticed. Sometimes there is not so much a limp, as a peculiar mincing way of walking.



FIG 79 Tuberculous disease of the ninth and tenth dorsal vertebræ

**Tenderness.** There is often, but not always, tenderness on pressure or on gentle percussion over the spinous processes of the affected vertebræ. Heavy percussion or forced passive movements may cause injury at the site of disease and must not be used during examination.

**Protective Muscle Spasm.** This is a constant feature. The spine is held rigid and stooping avoided; bending, as when picking up an object from the floor, is done from the hips and knees instead of the back. Spasm in small children is detected by lifting up the legs when lying prone.

**Deformity.** Some kyphosis is often visible early in the disease and may be the first thing to be noticed. To begin with there is no more than the slightest alteration in the normal curve, but later the angulation becomes acute and the spinous processes at the apex project like a knuckle



July, 1944



January, 1945.



August, 1945



April, 1948.

FIG 81 Tuberculous disease showing progressive destruction of bone followed by repair

**Type 2** (10 per cent). *Paraplegia associated in onset with early active disease but not recovering* even when the disease becomes quiescent. The ætiology is similar to Type 1. It can, in fact, be regarded as Type 1 gone wrong: this may happen because (*a*) the tuberculous disease has persisted for so long that damage to the cord, preventable at first, becomes permanent, (*b*) there is thrombosis of a vessel supplying the cord, or (*c*) the cord is damaged as a sequel to collapse of the vertebræ. Paraplegia accompanying collapse with severe angulation is not due to the cord being stretched round the angle, as might be supposed, but to loose sequestræ or masses of debris being forced backwards (Fig. 80). Very occasionally there is concertina collapse of the spine with nipping of the cord.



FIG 80 Tuberculous disease involving the ninth to twelfth dorsal vertebræ Note the "aneurism phenomenon" at the eighth and ninth vertebræ (p 105)

TREATMENT is of no value when there is thrombosis of vessels or concertina collapse. When there is compression of the cord, the neural canal should be exposed by laminectomy combined, if necessary, with costo-transversectomy. Surgical intervention sometimes enables partial recovery to take place.

**Type 3** (50 per cent). *Paraplegia occurring after the disease has apparently healed,* sometimes many years after. This is always due to reactivation of the disease and may be the first sign of recurrance. There is usually gross deformity dating to the time of the original attack, and not infrequently the deformity has been noticed to increase over a period of years even though the general health has been excellent. There is seldom

destruction gradually cease, recalcification commences and eventually a ring of dense bone forms around the diseased area (Fig. 81). Recumbency is continued uninterruptedly until healing is well advanced. Before the patient is allowed up there must be freedom from pain, a normal temperature, and radiological evidence of satisfactory recalcification. The usual time for a child is from one and a half to three years.

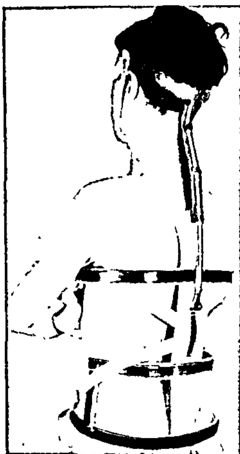


Fig 83 Brace for cervical caries

Some support for the back, either a plaster jacket or spinal brace, is essential when the patient first gets up (Fig. 83). He should lead a protected life and remain under the close supervision of the medical team that was responsible for his care in hospital. This entails regular clinical and radiological examination at that hospital or its associated after-care clinics.

**Spinal Fusion.** Operative fusion is often desirable at some stage but it must not be used as an alternative to prolonged recumbency. In Great Britain fusion is usually performed late with the threefold intention of protecting a well-healed lesion against trauma, of preventing an increase in deformity, and of maintaining compensatory curves. The best time for operation is thought to be after the patient has led an active life for several years with only the protection of a brace and without any sign of re-activation. At many clinics in the United States, however, fusion is performed at the commencement of the period of recumbency because it is considered that the efficient immobilization which it provides outweighs any disadvantages (p. 382).

## SACROILIAC TUBERCULOSIS

Tuberculosis affects the sacroiliac joints less often than the spine or hips but it is by no means infrequent. It occurs chiefly in young adults, the maximum incidence being between sixteen and thirty-five years of age. It is one of the more serious joint affections because of the frequency of associated tuberculous lesions and of sinus formation. Obvious tuberculous lesions are present elsewhere, often in the lungs or spine, in about one-third of all cases.

The overall mortality is high. In children it compares reasonably with other sites, but it rises with age until after forty the prognosis is bad. Seddon and Strange give some instructive figures on the effect of sinuses and associated lesions :—

pain. The overall recovery rate is about 65 per cent but the prognosis is better in adolescents than adults.

TREATMENT. Late paraplegia can be prevented by adequate initial treatment continued until there is proper healing with bony fusion, either spontaneous or operative. Once paraplegia has developed the treatment is conservative although operative evacuation of a paravertebral abscess is sometimes necessary.

## Treatment

The principles of treatment are the same as for tuberculosis elsewhere —rest with proper conditions of food and hygiene (p. 380). The conditions of rest are designed (*a*) to prevent as far as practicable all movement of the back, (*b*) to minimize bone destruction and prevent unnecessary deformity, and (*c*) to produce compensatory curves. This is best achieved by *immobilization on a frame although in some circumstances a plaster bed may* be preferable. At first the back is hyperextended; this position is not

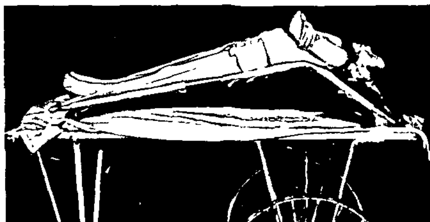


FIG 82 Hyperextension on a frame (Wingfield-Morris Orthopædic Hospital, by courtesy of Prof H J Seddon)

adopted with the idea of preventing ultimate collapse, but of protecting the diseased bones from pressure and unnecessary destruction during the active stage. Hyperextension is continued until the active stage is complete and then the vertebræ are allowed to fall together and compensatory curves are developed. Compensatory curves are produced by padding above and below the kyphus, and the closer the curves are to the kyphus, the better is the cosmetic and mechanical result. Careful watch is kept for abscesses presenting at the surface, and should this happen they must be aspirated regularly to prevent perforation of the deep fascia and skin.

Most frames are modifications of the Bradford frame and consist of a rectangle of metal tubing with canvas stretched across. The frame is bent to suit the individual patient and is readily adjusted as the occasion requires. It is mounted permanently on a carriage for easy transport in and out of the open air. An anterior plaster shell permits occasional removal from the frame without excessive movement of the back.

X-rays are taken at regular intervals throughout treatment and provide an almost cinematographic record of progress. Decalcification and

### Treatment

Conservative treatment is even more important than usual because of the frequency of associated lesions. The usual regime is instituted (Chap. XI) and the patient placed on a plaster bed or double abduction frame. Only a relative degree of immobilization can be obtained because movement of any part of the legs or spine affects the sacroiliac joints. Careful watch is kept for abscesses and the patient is turned on an anterior plaster shell once or twice monthly for inspection. Recumbency is continued until radiographs show commencing resolution ; this seems to occur more quickly than at the spine of hip, perhaps because treatment is often begun later.

**Operation.** Two operative procedures are commonly practised, excision of the diseased bone and arthrodesis.

Excision. The accessibility of the joint to radical surgery is a temptation to embark on complete eradication of the disease, but there is no evidence that the prognosis is thereby improved, or the period of treatment reduced. It should be considered only after a period of conservative treatment, preferably when the general condition is satisfactory and local resolution has commenced. Occasionally, however, excision is worth attempting as a last resort when the patient is unable to build up resistance against a massive infection. The usual procedure is that of *Piqué* who approaches the joint by removing the ilium posterior to a vertical line extending from the iliac crest to the sciatic notch.

Arthrodesis is used to provide protection after the active phase is arrested, or when the disease is quiescent. Extra-articular fusion can be carried out by *Verrall's* method in which a tibial graft is placed so that the ends pass through the overhanging portions of the ilium on each side, and the central part lies in a bed cut on the dorsum of the sacrum. *Campbell's* method is also suitable (p. 60).

## OSTEOMYELITIS

Acute osteomyelitis of the spine may be caused, as in other bones, by any pyogenic bacteria, but the commonest is the staphylococcus aureus (Chap. X). The infection is usually blood-borne although an infected lumbar puncture needle is an occasional source of trouble.

There are three types :—

(1) More often seen in children and adolescents. The osteomyelitis is but part of a fulminating septicæmia and calls for no local treatment.

(2) Usually seen in adults :—

(*a*) The initial infection is in the neural arch or its appendages. The onset is often acute with high fever, extreme tenderness, rigidity of the spine and subcutaneous œdema.

(*b*) The initial infection is in the body. The onset is usually insidious, and for months the cause of the illness may pass unrecognized until at last a deformity develops which resembles that in tuberculosis. At first there may be only general malaise and irregular pyrexia, a

Isolated lesions, closed, mortality within six years—9 per cent.
Isolated lesions, with sinus, mortality within six years—25 per cent.
Associated lesion present, mortality within six years—55 per cent.

## Clinical Features

The principle symptoms are pain and limp. The onset is insidious and the diagnosis is often overlooked until pain has become prominent. Pain may be felt at the sacroiliac joint, in the low lumbar spine, in front of the hip or it may be referred along the course of the sciatic nerve. Limp may be due to an abscess tracking in front of or behind the hip joint, or it may be associated with the "scoliosis" which not infrequently develops.



FIG 84 Tuberculous disease of the left sacroiliac joint

*Abscess* formation is very common and sometimes the first sign to appear. The abscess usually presents posteriorly over the joint but it may track to the loin, groin, buttock or indeed almost anywhere around the pelvis. Nearly half the patients have sinuses at some stage in the disease.

*Resolution* is by fibrous tissue formation leading to fibrous ankylosis. Spontaneous ossification takes place in many cases over a period of years, even in the absence of secondary infection. Sinuses persist more or less permanently in about half the patients developing them.

**X-rays** (Fig. 84). At an early stage, diagnosis may be difficult because the general rarefaction of bone usually seen around joint tuberculosis is often absent. The earliest sign is erosion of the joint surface, and later there is cavitation of the adjacent portion of the sacrum or ilium. Erosion and destruction may be limited to part of the joint or involve the whole of it. The joint space may appear narrower or broader; it is narrower when the joint surfaces are destroyed and the bones fall together, but broader when bridges of stronger bone remain and prevent collapse.

by laminectomy. If there is gross destruction of bone, the spine should be protected during consolidation, usually by recumbency on a plaster bed.

Osteomyelitis of the spine is rather uncommon and there has not yet been sufficient experience with penicillin to judge its effect on the course. Many patients are treated for pulmonary infection by the exhibition of sulpha drugs or penicillin before osteomyelitis has been diagnosed, and it may well be that the latter often passes unrecognized ; there are, however, almost certain to be X-ray changes in the vertebræ as a permanent memorial.

## TUMOURS

Every benign or malignant tumour that occurs in bone may be found in the vertebræ, and also every distrophy of bone and many disorders of metabolism and of the blood. The whole range of diseases from giant cell tumour to sarcoma, from Albers-Schönberg's disease to achondroplasia, and from renal rickets to lymphadenoma, are seen occasionally, but too rarely to warrant separate description here.

### Carcinoma

The commonest malignant tumour to be found in the spine is a secondary deposit of a carcinomatous growth. Sarcoma, primary or secondary, does occur, but infrequently. The site of origin of metastatic tumours in the vertebræ is stated by Burns and Ellis to be prostate 40 per cent, breast 30 per cent, hypernephroma 7 per cent, and others comparatively rare. Metastases from the breast lodge in the vertebræ more frequently than in any other bone.

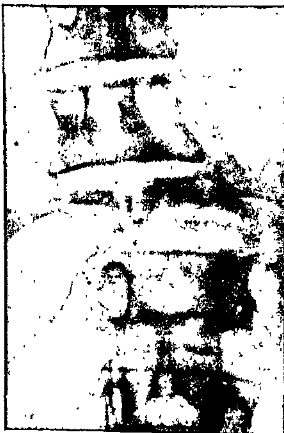


Fig 86 Secondary deposit in the eleventh dorsal vertebra from a carcinoma of the breast

Metastases are usually deposited in the bodies of the vertebræ which are rapidly destroyed by the growth and then collapse more or less completely (Fig. 86.) Sometimes, however, the bone increases in density to such an extent as to merit the description "ivory vertebræ" (p. 428). Pain at the site of the deposit is the outstanding feature but frequently there is also pain referred within the corresponding spinal segment. Examination shows local tenderness, restriction of movement due to muscle spasm, and also deformity where the affected bone has collapsed.

little pain in the back and some tenderness ; often flexion of the spine is markedly restricted whilst extension is free.

Mediastinitis is an almost invariable complication of infection of the body and leads sooner or later to the development of a mediastinal abscess, empyema or suppurative pericarditis. Respiratory symptoms are therefore prominent. The formation of an extradural abscess within the spinal canal not infrequently follows infection of the body, but seldom infection of the neural arch. The abscess or surrounding œdema may compress the spinal cord causing paraplegia.



FIG 85 Healed osteomyelitis of the bodies of the first, second, third and fourth lumbar vertebræ three years after the acute phase

**X-rays.** Radiological changes are slow to develop and none may be seen during the early weeks. The first sign when a body is involved may be narrowing of the intervertebral space. This is followed by changes in the trabecular structure of the bone and later the body is destroyed and may collapse. Sequestræ are common. During the healing stage much reactive new bone is formed with exostoses and bridges between the affected bodies (Fig. 85). Neural arch infection is harder to detect and may only be demonstrated after the bone has been destroyed. Oblique views are of value to show involvement of the lateral intervertebral joints.

**Diagnosis.** This is often exceedingly difficult because of the complex symptomatology which varies with the vagaries of secondary infection of other structures. Many patients, perhaps most, are first investigated on account of pulmonary symptoms. Attention should, however, be drawn to the spine by pain and tenderness on pressure over a spinous process and limitation of movements of the back.

**Treatment.** Chemotherapy has greatly altered both prognosis and treatment of infection in bone. Penicillin in massive doses controls infection by any sensitive organism but does not necessarily terminate the illness abruptly (p. 358). Extradural abscess requires immediate drainage

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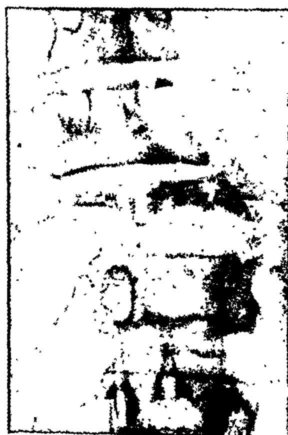


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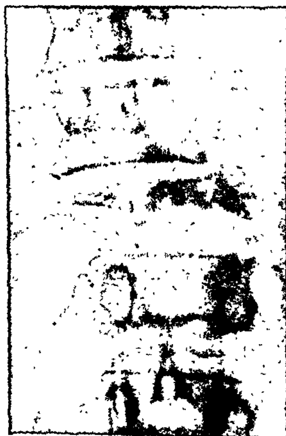


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Radiotherapy is often successful in relieving pain, and it may destroy the deposit enabling the bone to heal; even though the disease is not cured, life is prolonged. Occasionally the pain is so intractible that the only way of giving relief is by lateral or median cordotomy.



FIG 87 Angioma

## Angioma

This condition requires special mention because of its comparative frequency. Schmorl found angiomata in about 10 per cent of spinal columns examined post-mortem by serial section, and this has been confirmed by other pathologists. The number detected radiologically, however, is very much smaller, and those causing symptoms are fewer still. X-rays show a circumscribed area of very coarse trabeculation with approximately the same arrangement as in normal bone. Usually only one vertebra is involved, and chiefly the body of the vertebra, although in most instances the tumour spreads into the pedicle and transverse process on one side at least (Fig. 87.) Symptoms are uncommon but they may be caused by collapse or by pressure on the spinal cord.

CHAPTER IV

# THE HIP

The hip joint provides some of the major problems in orthopædic surgery. Functionally, it is one of the most important joints; it enables the body to move forwards during locomotion, it transmits the body weight, and it plays a major part in the regulation of posture whether standing or sitting. And because the hip moves with every change in position of the trunk or legs, a painful hip interferes greatly with normal activity. Unfortunately the structure of the joint is such as to render it particularly susceptible to disorders of a mechanical nature; it is a deep ball and socket joint and the very depth of the socket, although important in providing stability, has the disadvantage of requiring perfect congruity of the bearing surfaces, hence any defect seriously interferes with its smooth working. Moreover the blood supply of the head of the femur is less generous than is the case at other joints, and this often prejudices complete repair after injury or disease. It is, therefore, almost certain that every hip not mechanically perfect will sooner or later develop osteoarthritis; in fact this crippling complaint dominates the prognosis in all disorders of the hip, and it is an almost invariable sequel to injury or disease of every sort both in young people and in old.

The treatment of disorders of the hip is particularly difficult and calls for great judgment. When it is possible to restore congruity of the joint surfaces it is clearly desirable to do so even if, as may be the case with a child, it entails months or years of recumbency; but when it is certain at the outset that a perfect result is unobtainable, it is necessary to decide whether a difficult or a time-consuming procedure is likely to achieve a commensurate result. Some of the most difficult problems, however, are in connection with osteo-arthritis in elderly people because then the pain and disability suffered by an individual patient has to be assessed and weighed against the disadvantages of undergoing a major operation, perhaps followed by a prolonged period of after-treatment, and perhaps requiring extensive adjustment in the posture and function of other parts of the body.

On the other hand, the diagnosis of diseases of the hip is seldom difficult and it is only occasionally that a real problem arises, for example the early recognition of tuberculosis in children. It is unnecessary to burden the memory with the more complicated clinical procedures, such as mapping out Briant's triangle, because although almost every known disease of bones and joints can affect the hip, many of them are rare and

can be identified with certainty only after radiological examination. The commoner complaints can almost be diagnosed by the age at onset :—

| | |
|---|---|
| *Infants.* | acute suppurative arthritis. |
| | congenital dislocation. |
| *Children and adolescents.* | transient synovitis. |
| | tuberculosis. |
| | Perthes disease. |
| | adolescent coxa vara. |
| *Adults.* | osteoarthritis. |

## EXAMINATION

**Standing.** Deformity of the hip is reflected in the posture of the pelvis and spine (Chap. I). Flexion deformity is compensated, when the knee is straight, by lordosis which may completely mask the position of the hip (Fig. 89); but if the spine is stiff or the deformity is considerable, the knee cannot be straightened and only the toes touch the ground (Fig. 120, p. 149). Abduction deformity causes apparent lengthening of the limb, and



FIG 88 The relative length of the legs is indicated, when the patient is standing, by the height of one anterior superior spine above the other

adduction causes apparent shortening, because the pelvis is tilted sideways to make the legs parallel and the heel of the shorter side cannot be placed on the ground when the knees are straight (Fig. 90).

Real shortening is estimated at least as accurately when standing as it can be measured with a tape in the lying position. The patient stands with feet together, heels on the ground, and knees straight whilst the examiner places the thumb of each hand on the anterior superior spines of the ilium ; the vertical distance of one thumb above the other equals the real difference in length of the limbs (Fig. 88). A slight difference in length is quite common in "normal" adults who are seldom aware of it unless it exceeds one-third of an inch ; a smaller amount causes no symptoms and requires no treatment.

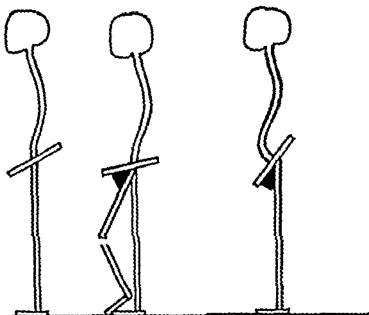


FIG 89

*Normal* *Flexion Deformity* causes apparent shortening *or* lordosis

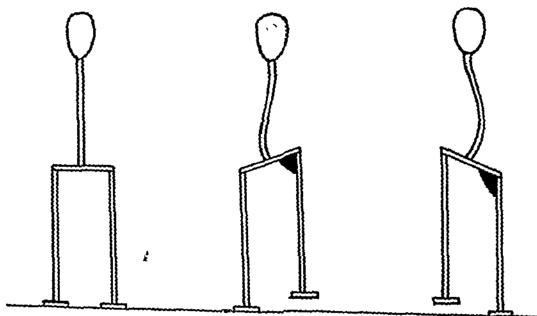


FIG 90

*Normal*

*Adduction Deformity* causes apparent shortening

*Abduction Deformity* causes apparent lengthening.

TRENDELENBERG'S SIGN is an index of the ability of the gluteal muscles to abduct the hip whilst weight-bearing. The sign is positive when abduction is impossible by reason of weakness of the glutei (e.g. due to anterior poliomyelitis), or because their leverage is reduced, as in congenital dislocation of the hip and coxa vara. It is elicited by instructing the patient to stand on the affected leg and raise the other knee as if marking time. Normally the buttock of the raised leg is lifted to a higher level than that of the standing leg; when the sign is positive, the buttock of the raised leg is lower than the other (Fig. 91). The explanation is that when the weight is transferred to one foot, the centre of gravity of the body has to be shifted to a position above that foot. This is normally done by the abductor muscles pulling the pelvis, and therefore the trunk, over the supporting foot. But when there is absolute or relative weakness of the glutei and the support of the opposite leg is removed, the pelvis falls and the centre of gravity is transferred to above the supporting foot by bending the trunk laterally in the lumbar region.

**Gait.** The cause of limp can be seen when the patient walks undressed. If the limp is caused by pain, the weight is lowered carefully onto the affected side, the knee bends slightly to absorb the shock, and the length of the step is shortened so that the weight can be taken off the leg quickly. If the limp is due to a stiff hip, the whole trunk and the affected leg are swung forward as one piece from the sound hip. If there is apparent shortening, the heel of the short side does not touch the ground. The Trendelenberg gait when Trendelenberg's sign is positive is characteristic and the trunk rolls across the supporting foot at each step.

**Lying.** Limitation of movement at the hip is masked by movement of the pelvis and therefore the pelvis must be watched whilst examining passive movements of the hip. One hand is placed on the pelvis and the leg is moved with the other; movement of the pelvis indicates that the limit at the hip has been reached.

The amount of fixed deformity of the hip is recorded in degrees. Abduction or adduction deformity is indicated by the angle between the line joining the anterior superior spines and the axis of the limb (Fig. 90). Rotation is noted both in extension and with the hip and knee flexed to a right angle. Fixed flexion deformity is demonstrated by flexing the sound leg until the knee touches the chest; this rotates the pelvis and extends the other hip which, when normal, should extend sufficiently for the leg to remain flat on the couch; inability to keep it flat indicates limitation of extension (*Thomas' test*, Fig. 92).

**Muscle Spasm.** This is pronounced whenever the joint is in an irritable condition due to an inflammatory process, either infective or traumatic. Movement is free during part of the range but it is suddenly checked by spasm which can be seen and felt, and the patient is apprehensive of any attempt to use force. *Gauvain's sign,* which is very commonly present in tuberculosis, is a special example of reflex muscle spasm. It is elicited by rotating the extended hip thus causing the abdominal muscles of the same side to contract.

Fig 91 Trendelenburg's sign is negative for the left hip and positive for the right

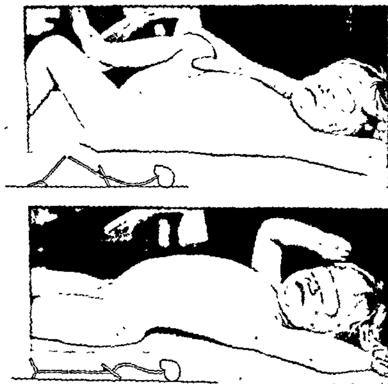


Fig 92. Thomas' test in a child with tuberculosis disease of the left hip

## INFANTS

Most infants with hip trouble come under observation because of difficulty in learning to walk, or because of some abnormality in gait, and it is only occasionally that the symptoms are painful or pyrexial. The commoner causes (at the hip) of limp in infancy are :—

| | |
|---|---|
| *In the absence of pain.* | Congenital dislocation of the hip. |
| *In the presence of pain.* | Apyrexial—tuberculosis of the hip (or spine). |
| | Pyrexial—acute suppurative arthritis. |

There is no normal age at which a child learns to walk. Individual variation is considerable and walking may begin at any time between about ten months and two years. Delay is not necessarily a sign of physical disease, or even of mental retardation, although either may be present. After walking has started various habits, such as intoeing, not infrequently develop ; they are due to temporary difficulty in co-ordination and are more of the nature of postural defects (Chap. I). Recovery can almost be guaranteed once organic disease has been excluded by full and sometimes repeated examination, including radiography, and no treatment is necessary. Spastic paralysis causes difficulty or delay in walking but as a rule it is easily recognized by the characteristic resistance of the muscles to passive movement (Chap. XV).

Congenital dislocation must be diagnosed at the earliest possible moment because the prognosis is largely determined by the age at which treatment is started. The only indication of abnormality may be a slight alteration in shape or symmetry of the limbs, or perhaps a small difference in the range of movements at the hips, and such observations by a mother should never be dismissed merely as worry about her child. Nor should reliance be placed on clinical examination alone because the diagnosis has been missed even by experts—X-rays must always be taken.

The presence of pain either in the hip or referred to the knee together with limitation of movement by muscle spasm is presumptive evidence of tuberculosis. Spinal caries may cause psoas spasm, restriction of movement at the hip and limp, therefore the investigation of limp must include examination of the spine.

## ACUTE SUPPURATIVE ARTHRITIS

Acute suppurative arthritis of the hip occurs more frequently in infancy and early childhood than in later years. It may be secondary to sepsis elsewhere, such as impetigo or otitis media, or it may follow pneumonia or one of the exanthemata. The symptoms are those of acute inflammation with abscess formation—sudden onset with high fever and general prostration, local swelling and extreme tenderness. The hip is held flexed and any attempt to move it is violently resented. Occasionally the infection is very mild and is distinguishable from tuberculosis only with difficulty.

Penicillin is the mainstay of treatment. It is given as early as possible and in large doses : for an infant not less than 100,000 units four-hourly

for the first forty-eight hours, and then 50,000 units four-hourly for at least a week. Although penicillin has greatly modified the severity of both course and prognosis, it is so important to avoid irreparable damage to the joint that local treatment is also desirable. When the diagnosis has been made within twenty-four hours of onset, it may be sufficient to aspirate the pus and instil penicillin in its place (p. 370). When treatment is begun later, the joint should be exposed and irrigated; the capsule is then sutured and penicillin left in the joint, but the more superficial layers of the wound are left open. The limb should be fixed in a plaster-of-Paris spica to ensure rest.



Fig 93 Suppurative arthritis of the hip



Fig 94 Suppurative arthritis of the hip at the age of 18 months; successful arthrodesis at five years.

Persistent suppuration destroys the articular cartilage and healing then occurs with a fixed joint. Not infrequently, however, the head of the femur is entirely destroyed, and sometimes the neck also, leaving an unstable hip (Fig. 93); it is then undesirable to permit weight-bearing or the femur will ride upwards on the ilium causing much shortening. It is difficult, and often impossible, to restore the length of the leg at a later date and therefore the hip should be stabilized as soon as possible. An ilio-femoral arthrodesis should be attempted (Fig. 94); the lower end of the graft may not unite, but the upper end will almost certainly fuse with the ilium and form a shelf which prevents upward displacement of the femur. Walking then causes no harm and union of the lower end of the graft can be secured by a further operation at a later date.

## CONGENITAL DISLOCATION OF THE HIP

The cause of congenital dislocation of the hip is probably to be found in an error of development in early fœtal life resulting from irregularity of mesodermal division. There is frequently a history of heredity (various authorities give from 15 per cent to 30 per cent), and it is significant that the incidence is greater in some districts, for example in parts of France and Italy, than in others. Females are affected more often than males, the proportion being about seven to one. Unilateral dislocation is somewhat more common than bilateral.

### Pathological Anatomy

The acetabulum is usually shallow; the iliac portion in particular fails to develop properly and this makes the acetabulum assume a more oblique position than normal. The head of the femur ossifies late and is displaced upwards and backwards to lie on the dorsum ilii. The joint capsule remains




FIG 95 Congenital dislocation of the hip in a child 23 months of age.

attached at approximately the normal points (the rim of the acetabulum and neck of the femur) and therefore it is elongated. After weight-bearing has commenced the head of the femur slides up the ilium and the capsule is still further stretched and becomes greatly thickened. Sometimes there is an "hour-glass" constriction of the capsule at the level of the upper border of the acetabulum which may be so marked as almost to divide the joint into two parts (Fig. 96). The ligamentum teres, if present, also becomes stretched and attenuated. Ultimately a false acetabulum may develop high up on the ilium and give some stability to the hip. The true acetabulum fills with fibro-fatty tissue.

The anteversion of the neck of the femur is increased. Normally the neck of the femur of a baby inclines forwards about 35° and the angle diminishes during growth to the adult angle of about 15°. In congenital dislocation of the hip, the angle at birth is larger than usual and it often fails to diminish during growth. It may be as great as 70° or 80° and then it is a factor of importance because the head of the femur is unable to engage the acetabulum properly and reduction is unstable.

## Clinical Features

Congenital dislocation of the hip should, in modern conditions, be diagnosed before or very soon after the child has begun to walk. Treatment is then likely to give good results; indeed reduction is only possible during early childhood. It is, however, only comparatively recently that early diagnosis has become common and untreated cases in older children and adults are still encountered.



FIG 96 Congenital dislocation of the hip with unstable reduction. Arthrogram shows an hour-glass constriction of the capsule (By courtesy of Mr F. C. Durbin )

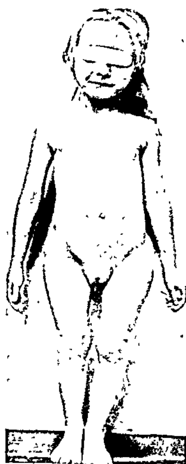


FIG 97. Bilateral congenital dislocation of the hip

Attention may be drawn to the hips before walking commences by some slight asymmetry or shortness of one leg. Often the mother notices a difference in the level of the gluteal folds, or of the creases on the inner sides of the thighs; or, with bilateral dislocation, the space between the thighs may be increased (Fig. 97). All children whose parents or relatives,

even distant relatives, were born with a dislocated hip should be X-rayed when a few months of age. Routine X-ray examination of all babies is practised in areas where congenital dislocation is endemic.

LIMP is usually the first abnormality to be noticed after the child has begun to walk. The limp is of the Trendelenberg type and it is easily overlooked when the dislocation is bilateral. Lordosis is marked because the head of the femur, in its abnormal position, is situated behind the centre of gravity and the body weight rotates the pelvis forwards.

TRENDELENBERG'S SIGN is always positive (p. 120). It can be elicited in an infant by getting her to climb on to her mother's knee. If she tilts the pelvis upwards as she lifts her leg, it is very unlikely that she has a dislocation of the hip of the side on which she is standing.



FIG 98 Shortening of the femur

REAL SHORTENING of the leg is always present and amounts to about half an inch to one inch. The shortening is in the thigh and is demonstrated when the child lies on her back with hips and knees flexed and feet flat on the couch: the knee on the affected side is then lower than that on the sound side (Fig. 98).

PALPATION of the head of the femur in an abnormal position is the most definite clinical finding. The head is apparent as a fullness on the dorsum ilii, and it can be felt to move when the hip is partly flexed and rotated from side to side.

TELESCOPIC MOVEMENT is sometimes present because of lack of support for the femoral head. It is demonstrated whilst the hip is partly flexed by pushing and pulling the leg in the longitudinal axis of the thigh.

**X-rays.** Interpretation may be difficult before weight-bearing has commenced. *The chief points are :—*

1. The head of the femur is always displaced upwards although the displacement may at first be so slight as to escape casual notice. Normally the upper border of the head is opposite the Y cartilage of the acetabulum.

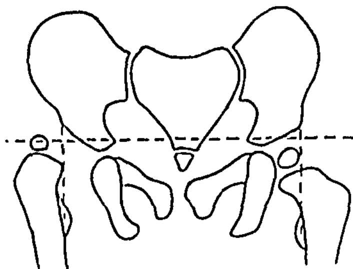


Fig. 99 Perkins' square

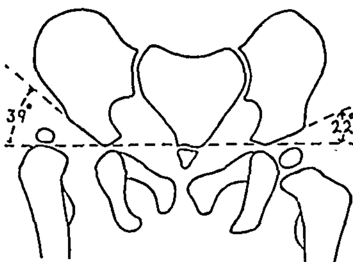



Fig. 100 Acetabular angle

2. The head of the femur should lie within the angle formed by the horizontal line passing through the top of the "Y" cartilage and the perpendicular dropped from the outer angle of the acetabulum (Perkins' square, Fig. 99).
3. Ossification of the femoral head is delayed.
4. The acetabulum is poorly developed, more so sometimes than others. The development of the acetabular roof is of prognostic importance. The angle formed between the horizontal and the plane of the upper half of the acetabulum is normally about 22° ; it is increased *in congenital dislocation, usually to between 30° and 40° (Fig. 100).* The nearer the angle to normal, the more likely is reduction to be stable.
5. Increase in anteversion of the neck of the femur shows as foreshortening, and when it is marked the neck and shaft lie almost in the same plane.

## Treatment

The aim of treatment is to place the head of the femur in the acetabulum and keep it there until proper development has taken place. Pressure of the head of the femur causes absorption of fibro-fatty tissue in the acetabulum and seems also to act as a stimulus to the growth of the acetabulum.

The methods of reduction and the precise indications for each vary with the individual surgeon but in Great Britain the tendency is to avoid open operation whenever possible. No method gives 100 per cent of successful results; up to the age of two, the best that can be expected with

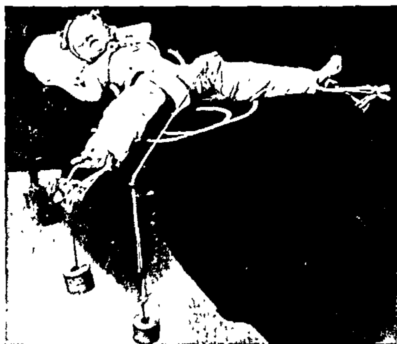


FIG 101. Reduction of congenital dislocation of the hip by gradual abduction Note the lateral pull applied to the left leg

unilateral dislocation is 80 per cent of successes, and with bilateral, 60 per cent. The results tail off rapidly as age increases until after six years a good result is improbable. The methods available, and the approximate age at which each is used, are as follows:—

<table>
<tr><td>Under one and a half years. Closed reduction by divarication</td><td rowspan="3">reconstruction operation if reduction is unsuccessful or unstable</td></tr>
<tr><td>One and a half to three years. Closed reduction by manipulation</td></tr>
<tr><td>Three to six years. Closed or open reduction</td></tr>
</table>

*Over six years.* Reconstruction or stabilization operation.

**Closed Reduction.** Manipulative reduction was introduced by Lorenz at the end of the last century (the bloodless operation of Lorenz) and was a great advance on previous methods. However, manipulation, specially if roughly performed, may entail some trauma to the head of the femur. The effect of this may be to cause osteochondritis of a type closely resembling Perthes disease and the prognosis is adversely affected. Reduc-

tion by gradual abduction of the hips is without trauma and is now the method of choice in infants.

DIVARICATION. Simple abduction of the hips is often successful in effecting reduction provided the head of the femur is not displaced too far up the ilium. Forrester-Brown's modification of Puttis divaricator is a convenient apparatus (Fig. 101). The legs are gradually abducted over a period of two or three weeks until nearly in a straight line with each other. The position of the hips and subsequent progress is controlled by X-rays. Full abduction is maintained for about nine months; it is then decreased and fixation is changed to plaster-of-Paris as in the later stages after manipulative reduction.



FIG 102 The Lorenz position

MANIPULATIVE REDUCTION. This may be necessary when there is gross displacement of the head of the femur. It is usually fairly easy up to two years of age but thereafter the difficulty rapidly increases because the muscles and fascia are contracted, the joint capsule is thickened, and there are changes in the acetabulum. Reduction is likely to be impossible or accompanied by excessive trauma after six years of age when the dislocation is unilateral, and after four years when it is bilateral. The method of manipulation is to exert traction on the flexed and abducted thigh and lever the head over the rim of the acetabulum.

After reduction, the hips are fixed in a double plaster-of-Paris spica; the plaster extends to the ankle of the affected leg or legs, but stops above the knee of a sound leg. The position of fixation should be that in which the hip feels most stable. In the *Lorenz* position, there is 90° flexion, 90° abduction and 90° external rotation; the patellæ face upwards and outward and the thighs and legs are in the coronal plane (Fig. 102).

Immobilization is continued until X-rays show that the acetabulum is developing and there is every prospect of the hip being stable; this usually takes from nine to eighteen months. The plaster requires changing

every three months, or more frequently if badly soiled. It is advisable to reduce the amount of flexion and abduction after nine months, if it can then be done without interfering with stability. The final plaster may be in 30° of flexion, 30° of abduction and neutral rotation, a position which permits walking whilst preventing re-dislocation. Towards the end of the period of fixation the plaster is split and the child removed once or twice a day for massage and exercises. The range of movements is allowed to increase under supervision until finally the plaster is omitted entirely. It takes at least a year after leaving off the plaster for walking to become normal. The *Batchelor* type of plaster which maintains abduction and rotation whilst permitting active flexion is useful in the later stages (Fig. 103)

Nursing a child in a plaster spica requires some ingenuity. Napkins can be avoided by keeping the child raised on pillows and leaving a receiver beneath her; or a board may be fixed in the cot at an incline and the plaster tied to it without the child feeling that she is being restrained. Older children are often happier lying face downwards during part of the



FIG 103. Batchelor's plaster

day because it is then easier to look around and play; they propel themselves about the floor with hands and elbows in an astonishing fashion, and even walk if given the chance.

**Operation.** OPEN REDUCTION may be necessary in patients under six years old when closed reduction has failed, or would clearly be unsuccessful. It is always preferable to the use of excessive force at manipulation with the attendant risk of damage to the head of the femur. An arthrogram may be of help when making a decision.

Operation requires considerable judgment and should only be attempted by a surgeon with special experience in this class of work.

Weight-traction applied to the leg for a few days is a useful preliminary, but the adductors may still need tenotomy to allow the head to be brought down to the level of the acetabulum. The obstruction to reduction may prove to be an hour-glass constriction, or the acetabulum may be covered by a fold of the lower part of the capsule, or the capsule may be adherent to the ilium, or sometimes a mass of fibro-fatty tissue requires gouging out of the acetabulum. It may be advisable to perform a reconstruction operation at the same time as reduction. After operation a plaster spica similar to that used after closed reduction is applied. Fixation is seldom necessary for longer than nine months.

Reconstruction Operation. This is designed to increase the size of the upper lip of the acetabulum when it fails to develop sufficiently. It is performed :—

1. After closed reduction when there is clinical evidence of instability and radiography shows a poorly developed acetabulum.
2. At the same time as open reduction when acetabular development is seen to be poor.
3. In the event of re-dislocation, even if a considerable time after reduction.

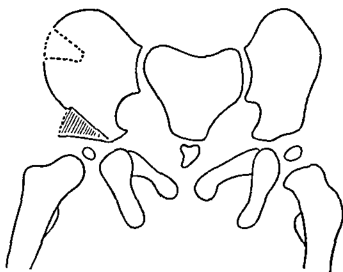


Fig 104 Reconstruction of upper lip of the acetabulum

The operation is conveniently performed through a window cut in a previously applied plaster spica. It consists in depressing the roof of the acetabulum and turning down a flap of the outer table of the ilium above and towards the front of the acetabulum ; the gap is filled with a graft cut from the ilium (Fig. 104). Consolidation is rapid and weight-bearing can usually be commenced after three months.

Rotation Osteotomy. The question of excessive anteversion of the neck of the femur should be considered before deciding on a reconstruction operation. When the neck of the femur points almost forwards, the head is able to engage the acetabulum only whilst the leg is rotated inwards ; in these circumstances an osteotomy is performed just below the lesser trochanter and the leg is externally rotated the required amount.

## Adults

Unreduced dislocation nearly always gives rise to symptoms sooner or later. A false joint on the dorsum ilii does not often develop arthritis because it is very shallow, but occasionally there is some pain due to the excessive strain on the capsule and ligaments. Symptoms in adults most frequently occur in connection with the lumbar lordosis which places the spine at a mechanical disadvantage and may cause severe backache. Palliative treatment gives but temporary relief and operation is often

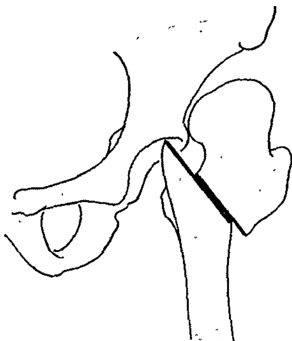


Fig 105 Lorenz bifurcation osteotomy

necessary. The problem is to alter the line of transmission of body weight so that the pelvis can rotate backwards and reduce the lordosis.

*The Lorenz bifurcation osteotomy* has this effect and on the whole gives satisfactory results. It may also be helpful when there is pain at a false acetabulum. The femur is divided obliquely from below upwards and inwards, and the point of the distal fragment is forced inwards as far as possible towards the acetabulum (Fig. 105). A double plaster spica is applied until union is secure, about three months. Physiotherapy and postural re-education are an essential part of the after-care.

*Vitallium cup arthroplasty* can be performed with success in some circumstances and always requires consideration.

Successful reduction in early childhood followed by good development of the acetabulum gives perfect function for many years, but it is now becoming apparent that these hips, even when the radiological appearance is perfect, tend to wear out after forty or fifty years and become osteoarthritic. Osteoarthritis develops earlier when there has been osteochondritis and the head of the femur is deformed. The treatment is as for osteoarthritis due to other causes and the pain is often severe enough to demand operative relief (p. 150).

## CONGENITAL COXA VARA

This is a rare condition in which there is a congenital defect in development of the neck of the femur. A number of variations have been described, but Campbell Golding has been able to follow the X-ray changes in several patients throughout the period of growth and has shown that most of them, and also micromelia due to a short femur, are really different degrees and different stages of the same condition (Fig. 106).

The only available treatment is to restore the angle of the neck by abduction osteotomy.




FIG 106 Congenital coxa vara and short femur (By kind permission of Dr Campbell Golding and the Editor, *Journal of Bone and Joint Surgery*)

The radiographic features, not all of which are present in every case, are given below (Golding) :—

1. An oblique or vertical defect in the neck which gives the appearance of cutting off a triangular fragment from the anterior-inferior angle. There may be a second triangular fragment at the antero-superior angle.
2. A varus deformity.
3. A short neck.
4. A fragmented neck.
5. Delay in ossification of the neck and upper part of the shaft of the femur.
6. Incomplete ossification of part of the neck.
7. Beaking of the great trochanter.
8. A facet formed on the ilium by the abnormal trochanter.
9. Secondary deformity of the acetabulum due to the malposed head.
10. Shortening of the shaft of the femur.

## CHILDREN AND ADOLESCENTS

| | | | |
|---|---|---|---|
| *Transient synovitis* | all ages | | |
| *Tuberculosis* | all ages | maximum 2-7 | years |
| *Perthes disease* | 3-16 years | „ 4-9 | „ |
| *Adolescent coxa vara* | 8-19 years | „ 12-15 | „ |

## TRANSIENT SYNOVITIS

The symptoms of early disease of the hip of whatsoever type are pain, deformity and limp. It cannot be emphasized too strongly that every patient with symptoms or physical signs referable to the hip must be regarded as suffering from serious organic disease until the contrary is proved. Although transient symptoms are common and account for perhaps four out of every five cases in younger children complaining of the hip, it is impossible, in the absence of radiological changes, to distinguish them from symptoms due to major conditions.

The reaction of the hip to minor injury is the same as elsewhere but it is less readily appreciated because the joint is deep-seated and is not readily examined by palpation. It differs from, say, the knee where the presence of periarticular swelling, localized tenderness and fluid can readily be determined. At the hip the usual physical signs of swelling and tenderness are often unobtainable, and since muscle spasm and restriction of movement may be the only evidence of disorder, a positive diagnosis of a sprain cannot be made.

Tuberculous disease may cause symptoms before destruction of bone is sufficiently advanced to be demonstrable radiologically. It is, therefore, essential that every patient with physical signs at the hip is put to bed immediately and kept at rest. It is advisable to apply extension to the limb but no elaborate apparatus is necessary ; a five pound weight attached to the leg by adhesive strapping and hung over the foot of the bed is sufficient. The majority of patients with only simple synovitis will be free of signs after ten to fourteen days and may then be allowed to get up. They are re-examined after a further fourteen days and if there are still no signs of disease, it can be said with some assurance that none is present. If any signs or symptoms persist, the cause will soon be revealed radiologically.

## TUBERCULOSIS OF THE HIP

Tuberculosis of the hip is essentially a disease of childhood. Nine out of ten cases occur during the first decade of life, and about half of these between three and five years of age. Males are affected slightly more frequently than females.

The infection, as with all tuberculosis of bone, is invariably secondary to a primary site elsewhere in the body. The common starting points in the hip are shown in order of frequency in Fig. 107. The initial focus enlarges and quickly spreads to the joint, involving first the synovial membrane and then the adjoining surfaces of the acetabulum and head of the femur.

Soon the whole joint is destroyed and replaced by tuberculous granulation tissue.

The disease runs a course lasting two to three years; the length is not greatly influenced by treatment although the amount of destruction of bone may be modified, and secondary infection and deformity can be prevented. Healing is by fibrous replacement of the tuberculous tissue. The resulting fibrous ankylosis has considerable firmness although it may yield gradually with the passing of years and permit the return of deformity. Moreover, small foci of living tubercle bacilli are sometimes encapsulated in the fibrous tissue where they remain as a permanent menace and therefore the hip cannot be regarded as secure unless there is bony ankylosis; this does not occur spontaneously in the absence of secondary infection and often has to be attained by operation.

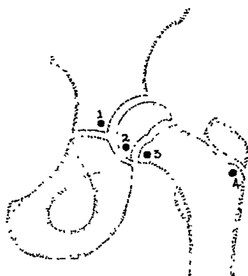



FIG 107 The starting points in tuberculosis of the hip. (Reproduced from "Recent Advances in Orthopædic Surgery" by kind permission of Mr B H Burns and Mr V. H Ellis)

The disease may remain extra-articular when the initial focus is at the base of the neck of the femur (Fig. 297, p. 382), and also occasionally in metaphysial infection. It is so important to prevent the spread of infection into the joint that, in those few cases in which there is a reasonable chance of success, excision of the focus may be attempted. Operation, however, is not in place of, but additional to general treatment which must be continued until the outcome is certain.

## Signs and Symptoms

**Early.** LIMP and PAIN are the important early symptoms, limp as a rule being the more significant. The onset is insidious; at first there may be nothing but a limp which is present only when the child is tired and disappears after rest. Later the limp becomes constant, and some aching at the hip and general fatigue may be noticeable. Pain is seldom prominent and it is felt as often at the front of the thigh and inner side of the knee as at the hip. On examination, there is usually a little restriction of move-

ment in every direction, and possibly tenderness over the joint. The hip may be held in slight flexion, abduction and external rotation, the position in which the capacity of the joint cavity is said to be greatest (Fig. 108).

This is the picture at the early stage when there is synovial irritation and effusion, but before the disease has invaded the joint. This is the time to commence treatment, therefore every child limping without obvious cause must have the hips (and back) examined; if there is any tenderness, limitation of movement or spasm, and even if X-rays are negative, that child must at once be put to bed.



Fig. 108 Early tuberculosis of the hip Note the flexion deformity and compensatory lordosis

**Intermediate.** As the disease progresses and there is more extensive involvement of the joint, MUSCLE SPASM and DEFORMITY become the prominent features. On examination, there is muscle spasm induced by any attempt to force movement, and obvious limitation of movement in every direction. Gauvain's sign (p. 120) is almost always positive. There may be a little muscle wasting. Deformity is caused by spasm which draws the hip into a position of flexion, adduction and internal rotation, thus producing the classical posture of the tuberculous hip—apparent shortening and lordosis. Thomas's test (p. 120) confirms the presence and extent of flexion deformity.

**Late.** GROSS WASTING, SWELLING of the joint and REAL SHORTENING are late signs which only become apparent when bone destruction is advanced. Wasting affects all the muscles of the limb but is more marked in the thigh and buttock than in the calf. Swelling is due to distension of the joint with tuberculous material. Real shortening occurs when there is gross destruction of the head of the femur and acetabulum, and when the joint is dislocated.

ABSCESS FORMATION, which occurs in about 50 per cent of all patients, is the result of perforation of the joint capsule by tuberculous material. The abscess may present at the surface anteriorly between the sartorius and tensor fasciæ femoris, or pass internally between the adductor muscles; it may also collect deep to the glutei, and occasionally it perforates the acetabulum to form an intra-pelvic abscess.

**X-ray Appearances.** At a very early stage the joint space may be slightly increased by effusion, but there is no alteration in the structure of the bone. After involvement of the joint, the articular cartilage is eroded and the joint surfaces of the bones are attacked by the disease; the cardinal features are then :—

1. Narrowing of the joint space.
2. The outline of the bone loses sharpness and becomes ind

3. Rarefaction of all the bones for some centimetres around the joint.

As destruction of bone proceeds, the trabecular structure is lost and cavities appear and later coalesce (Fig. 109). The extent of irreparable bone destruction varies; it may be negligible or there may be virtual destruction of the whole head of the femur and acetabulum. When there has been inadequate protection from muscular spasm, pressure of the head of the femur on the softened acetabulum causes it to travel upwards and backwards (wandering acetabulum) and finally the head may dislocate on to the dorsum ilii.



FIG. 109. Tuberculosis of the hip

## Treatment

**Conservative.** GENERAL TREATMENT to increase resistance to the infection is essential and it is now almost universally carried out at an open-air hospital. Ambulant treatment and primary operative measures have had their vogue and for the most part have been abandoned. At some clinics in the United States, however, arthrodesis is performed whilst the disease is still active because fixation is then more efficient and it is thought that healing takes place more quickly (p. 382).

LOCAL TREATMENT is directed towards minimizing the amount of bone destruction and assisting resolution to take place without deformity. During the stage of active bone destruction, extension is *applied to the* limb in order to provide rest, relieve pain and spasm, correct deformity, and prevent [illegible] re of the head of the femur. Dur [illegible] replaced by a plaster spica which [illegible] er, and allows fibrous ankylosis to take place in the best position.

The *method* of applying extension varies with the hospital. The Robert Jones abduction frame has the advantage of immobilizing the trunk as well as both legs (Fig. 110). It is simple to make and apply, and allows easy nursing and free inspection to detect abscess formation; it is light enough to carry although movement to and from the open-air is simplified when the frame is mounted on a trolley.

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1. Narrowing of the joint space.
2. The outline of the bone loses sharpness and becomes indefinite.

prevented by the tendency of the hip to flex and adduct thus separating the graft and the great trochanter.

(*b*) *Ischio-femoral Arthrodesis* (Brittain). A massive graft from the tibia is passed through a gap cut in the femur by subtrochanteric osteotomy and embedded in a notch made in the ischium (Fig. 112). Union takes four to five months but is very strong. This method may be employed in adults before the disease is completely quiescent because it does not prevent the upward thrust of the femur which is desirable to obliterate potential spaces where the bone has been destroyed (Fig. 298, p. 383).

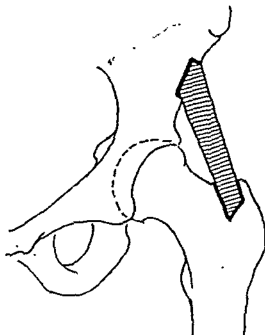


Fig. 111 Ilio-femoral arthrodesis

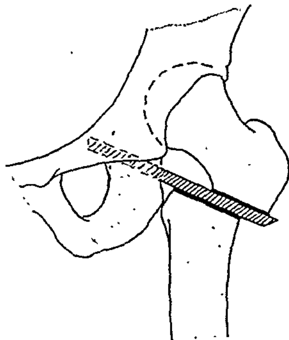


Fig 112. Ischio-femoral arthrodesis (Brittain).

2. Disease Still Active. (*a*) *Children*. When bone destruction has ceased but the commencement of resolution is delayed, when progress is "*hanging fire*," there may be a favourable reaction to almost any operation in the region of the hip. An example is sub-trochanteric [illegible] a procedure which has the advantage that [illegible]

[illegible] mes rewarded by a brilliant [illegible] without risk to life. It is of value, particularly in adults, when there are sinuses that have failed to respond to conservative treatment.

(*c*) *Extra-articular Infection*. A focus at the base of the neck of the femur, or a metaphysial focus that has not invaded the joint, can be removed at operation. It is most unusual for a metaphysial focus to be detected at this early stage, and on many occasions when this was thought to be the case, operation has revealed a perforation into the joint and has done more harm than good.

Extension is continued until the radiographs, which are taken at three monthly intervals, show that bone destruction has ceased. A double plaster spica is then applied to include the whole leg on the affected side and the other thigh. The plaster is bivalved to permit regular inspection of the joint. The patient is kept in bed in plaster until the disease is quiescent and [illegible] 'o three years after the onset. [illegible] of protective apparatus, usu. [illegible] Protection is continued until there is no longer any tendency to deformity, preferably until after there is bony ankylosis, spontaneous or operative. In a very small number of patients there is little destruction of bone, healing occurs without ankylosis and a useful range of movements is regained after all apparatus has been discarded.

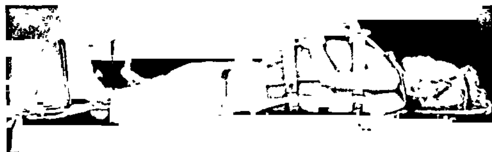


FIG 110 Tuberculosis of the hip treated on a double abduction frame. (Winfield-Morris Orthopædic Hospital, by courtesy of Prof H J Seddon)

A sinus gravely affects the prognosis because of the risk of secondary infection. Every care must be taken, therefore, to detect and treat an abscess immediately it forms and prevent it bursting. Treatment is by aspiration repeated as often as may be necessary. Evacuation through an incision should be avoided when possible because of the danger that a sinus will subsequently form in the scar.

**Operative.** It is generally held that operation has no place in the routine treatment of active intra-articular disease, although this view is challenged by some surgeons who consider early arthrodesis to be of value. The indications for operation are :—

1. DISEASE QUIESCENT. When the disease has healed with fibrous ankylosis, arthrodesis is the only form of perr [illegible] joint, and the best insurance against re-activatio [illegible] until after twelve years of age because of the di [illegible] when younger.

Arthrodesis in tuberculosis is usually performed by an extra-articular route to avoid entering a potentially infected area. There are two methods :—

(*a*) *Ilio-femoral Arthrodesis.* A strut of bone cut from the ilium or the tibia is placed between the great trochanter and the ilium immediately above the acetabulum (Fig. 111). Fusion occurs with some certainty at the upper end of the graft, but union at the lower end is frequently delayed or



Fig 113 Perthes disease at a fairly early stage, showing an increase in joint space and fragmentation of the epiphysis.



Fig 114 Perthes disease with marked changes in the metaphysis

seldom retains its normal shape and the acetabulum adapts itself to any alteration ; at best, the head is a little broader than normal, and at worst, it is compressed into the mushroom shape of the classical descriptions of the disease (Fig. 115). The neck of the femur remains permanently broadened, and it may also be shortened if the rarefied metaphysis is allowed to collapse.

The "capital index" is the ratio of the maximum height of the head of the femur to its width measured along the epiphysial line and multiplied by 100. It is used as an indication of the amount of flattening of the head. In normal children the "capital index" is little under fifty, but in Perthes disease it may be as small as twenty.

X-rays (Figs. 113 and 114). The earliest changes (*stage of onset*) are :—

1. Increase in size of joint space.
2. Increased density of the epiphysis.

## PERTHES DISEASE

(*Synonyms*) Pseudocoxalgia, Calvé-Legg-Perthes disease, coxa plana, osteochondritis deformans juvenilis, quiet hip disease.

Perthes disease of the hip is usually included in the group of affections of the epiphyses and small bones known as *osteochondritis juvenilis.* The commoner are Schlätter's disease of the tubercle of the tibia, Köhler's disease of the tarsal scaphoid, Sever's disease of the apophysis of the os calcis, and Freiberg's disease of the metatarsal heads, but changes of similar type have been described in many other bones.

The ætiology is obscure and in spite of much experimental work no acceptable conclusion has been reached. The theories advanced include trauma, vascular disturbances, mild chronic infection and congenital predisposition ; that most favoured at present is trauma associated with vascular disturbance, but it is probable that no one cause is responsible for all cases.

The affection appears to run a definite course lasting from one to three years, which can conveniently be divided into three stages—onset, activity and healing (Platt). The initial stages are degenerative with marked trabecular absorption. Whilst the disease is active, the bone is soft and is readily deformed by pressure ; since no re-moulding occurs, any distortion in shape is permanent. During the stage of healing, new bone is laid down and the intimate structure returns to normal.

### Clinical Features

The onset may be at any age from four to sixteen years with a maximum incidence from four to nine years. The disease is two or three times as common in boys as in girls and it is usually unilateral although bilateral involvement is not uncommon.

The Stage of Onset is clinically indistinguishable from tuberculosis. The first complaint is usually of limp, and although pain may be present it is not a marked feature. Examination shows muscular spasm and limitation of movement ; restriction of abduction and adduction is often more marked than restriction of flexion and extension. Spasm and limitation of movement disappear rapidly with rest but return if weight-bearing is resumed.

The Stage of Activity follows rapidly and lasts for about two years. On examination during treatment there may be a complete absence of abnormal physical signs, nevertheless treatment must be continued for as long as X-rays show the bone to be soft. At the conclusion of the stage of healing, it will almost always be found that the clinical findings are more favourable than the X-ray appearance suggests they should be ; there is seldom pain or limp and the range of movements is good. The ultimate prognosis, however, does not depend on the immediate clinical findings, and unless the shape of the hip is all but perfect, osteoarthritic changes are bound to occur sooner or later.

Stage of Healing. The epiphysis commences to regenerate and the structure of the bone slowly returns to normal. The head of the femur

## ADOLESCENT COXA VARA

(*Synonym*) Slipped femoral epiphysis

There are several causes of varus deformity of the neck of the femur :—

1. Adolescent coxa vara.
2. Fracture of the neck of the femur, usually a basal fracture, permitted to unite without proper reduction, or to bend because weight-bearing has been commenced too early.
3. Metabolic diseases such as rickets and osteomalacia causing softening of the bone severe enough for it to bend under the weight of the body (p. 131).
4. Congenital coxa vara (p. 133).

*Adolescent coxa vara* is a condition in which the upper femoral metaphysis is in an abnormal state which renders the epiphysis liable to displacement. The name is derived from the deformity which occurs in the majority of patients, but deformity is not an inevitable sequel. Displacement is often gradual, sometimes it is bilateral, and very occasionally there is simultaneous separation of other epiphyses. The disease can occur at any time between eight and nineteen years of age but it is commonest between twelve and fifteen, and it is seen much more frequently in boys than in girls.

The pathology is not understood but it may be significant that most cases occur in the same physical type—fat children, many with a definite Fröhlich syndrome. Trauma often plays a part but its relation to the onset of symptoms is variable. Frequently no history of injury can be obtained ; sometimes an injury, usually comparatively trivial, precedes the onset of symptoms by days or weeks ; at other times trauma occurs after symptoms have been present for some weeks and causes a sudden exacerbation.

### Clinical Features

There are three distinct stages :—

STAGE 1. *Before there is any slipping, or whilst it remains minimal.* It is probable that symptoms do not occur until after slipping has commenced. The earliest displacement is rotation ; this is not easily detected in antero-posterior radiographs and may therefore be missed, but it is obvious in lateral views (Fig. 116).

Pain is the outstanding symptom and usually the first to be noticed ; it commences gradually and is often referred to the inner side of the knee. Limp due to muscle spasm develops as the pain increases. On examination the only findings are muscle spasm and slight limitation of abduction. The stage of minimal slipping may last for some weeks and, if treatment is begun in time, further slipping can be prevented.

STAGE 2. *After gross slipping has taken place.* The patient may first come under observation after gross slipping has taken place. Sometimes this occurs gradually, but sometimes it happens suddenly, either with or without trauma. The direction of displacement is such that the neck of the femur moves upwards in relation to the head, and it also rotates so that the epiphysial surface of the neck faces forwards and upwards (Fig. 118).

The classical appearance develops later (*stage of activity*).

3. Fragmentation and condensation of the epiphysis.
4. Metaphysial rarefaction giving an appearance of cavitation, often most marked at the inner end of the epiphysial line.
5. Obliteration of trabeculæ in the subchondral area.
6. Flattening and mushrooming of the epiphysis.
7. Broadening of the neck of the femur.



FIG 115. Untreated Perthes disease

## Treatment

The immediate good results following any treatment, or no treatment at all, have in the past tempted surgeons to be unjustifiably optimistic and serious attempts to preserve the shape of the head have been made only in recent years. The ambulant methods hitherto practised do not give complete relief from pressure and nothing less will suffice to protect the head. It is essential to maintain recumbency, and to hold apart the surfaces of the joint by continuous traction. Fixed traction on a frame as in tuberculosis may be used, but weight traction with the leg supported on a counterbalanced Thomas's splint is probably adequate and gives the patient a more tolerable existence.

Treatment must be continued until the stage of activity is complete and healing has advanced to a point at which the bone is strong enough to take pressure without being distorted. No method is known that will reduce the time taken by the disease to run its course, nor is there any method of restoring the shape of the head of the femur to normal after it has been deformed. The only hope of complete success is to make the diagnosis before there is any serious change in shape and then to prevent such a change occurring. Two years or more may seem a long time in hospital for a child suffering from a disease that does not endanger life, but the reward of a sound hip may make it worth while, specially now that educational facilities are available at all long-stay orthopædic hospitals.



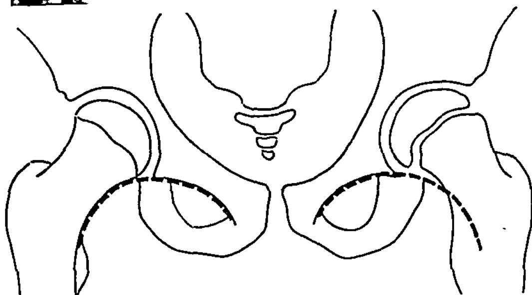


FIG 117 Adolescent Coxa Vara with displacement visible in the antero-posterior view
The diagram shows Shenton's line

## Treatment

Every child with symptoms directed to the hip, that is every child complaining of pain or limp, should be put to bed with extension applied to the limb until a diagnosis is made. This is the treatment of the first stage of adolescent coxa vara, and of Perthes disease, and it is a good start with the treatment of tuberculosis.

STAGE 1. When diagnosis is early reduction is unnecessary; gross displacement must, however, be prevented and therefore extension is applied with 5–10lbs. weight, the limb being supported on a counter-balanced Thomas's splint. Extension must be maintained until the metaphysis has regained its normal structure; sometimes this takes no more than three months, but nine to twelve months may be required.

Fixation with a tri-fin nail as for an intracapsular fracture of the neck has many advocates. It is certainly justified when healing is delayed, and there is much to be said for operating early, even when slipping is minimal, because weight-bearing can safely be resumed as soon as the wound is healed.

Pain is usually greater than during the first stage; limp also is increased and is due to deformity as well as to spasm. There is an adduction—external rotation deformity and the limb cannot be abducted or internally rotated. There is apparent shortening to compensate for the adduction deformity (p. 118), and real shortening of ½ inch to 1 inch depending on the amount of upward displacement of the neck.

STAGE 3. *Healing.* The intimate structure of the bone returns to normal. Premature closure of the epiphysis is the rule when there has been gross displacement, but it does not always occur after a minor degree of slipping.

Pain disappears during this stage, but if there is much displacement, limp and deformity remain. Osteoarthritis is the inevitable sequel of deformity and the late prognosis is bad unless displacement is arrested during the first stage, or unless a good reduction is obtained without trauma.

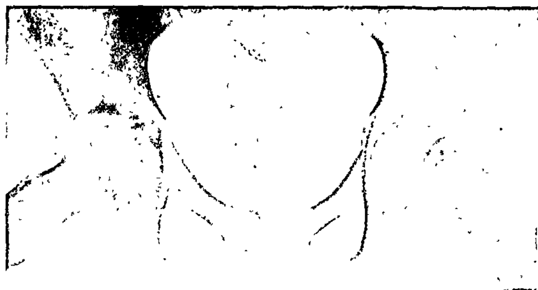


FIG 116 Adolescent Coxa Vara Stage 1, lateral view There was no visible displacement in the antero-posterior view although metaphysial changes were shown

**X-rays** (Figs. 116, 117 and 118). During the first stage slipping may not be apparent in antero-posterior films although lateral views show slight external rotation of the neck in relation to the head. After the typical deformity has developed, the neck is displaced upwards and rotated outwards and upwards, the lower margin of the neck perhaps lying opposite the centre of the head.

There is always some change in the structure of the metaphysis which may be slight or may be marked. In a severe case there is a band about 1 cm. wide in which the bone is rarefied and there may be areas of trabecular absorption giving almost a cystic appearance. The neck often becomes rather broader and shorter.

*Shenton's line* is a useful guide to upward displacement of the neck of the femur. Normally the curve of the upper border of the obturator foramen is continuous with that of the lower border of the neck, but this line is broken when the neck is displaced.

# ADULTS

## RHEUMATOID ARTHRITIS

Arthritis of the rheumatoid type occurring at the hip is almost always part of a generalized arthritis. It occurs at any age from childhood (Still's disease) to late middle-age and its general features are the same as elsewhere (p. 387). Ankylosis is common. Sometimes the acetabulum becomes very deep and its inner wall bulges into the pelvis (protrusio-acetabuli). Osteoarthritic changes are frequently superimposed when some movement remains after the rheumatoid process has subsided. Local treatment follows the same lines as for osteoarthritis of the hip, but it is exceptionally difficult because the condition is usually bilateral, movement is often greatly restricted and the muscles are atrophic.

## OSTEOARTHRITIS

### Ætiology

Osteoarthritis is the predominant hip disease of adult life but every sort of bone and joint disease involves the hip from time to time. The high incidence of osteoarthritis is explained by the shape of the joint, and perhaps by the comparatively poor blood supply of the head of the femur. Lack of congruity of the joint surfaces, from whatever cause, interferes with smooth movement of the joint which then wears out rapidly. Most if not all the conditions listed below cause osteoarthritis for this reason.

1. *Trauma.*
2. *Pre-existing disease.*
    - congenital dislocation.
    - Perthes disease.
    - adolescent coxa vara.
    - rheumatoid arthritis.
    - suppurative arthritis.
    - gonococcal arthritis.
3. *Congenital subluxation and shallow acetabulum.*
4. *Degenerative vascular changes.*
5. *Local disease.*
    - cysts and tumours of bone.
    - synovial osteochondromatosis.
6. *Local manifestations of general disease.*
    - Paget's disease.
    - osteitis fibrosa.
7. *Diseases of the central nervous system.*

Congenital subluxation is insufficiently appreciated as a cause of osteoarthritis of the hip although it is responsible for many of the bilateral cases. Neither the acetabulum nor the head of femur are of normal shape and the acetabulum may be so shallow as to accommodate little more than half the head. Wiberg found X-rays of forty-four such cases

STAGE 2. Treatment is more uncertain because although reduction of the displacement is desirable, it may be difficult or impossible. Forcible reduction by manipulation is frequently followed by permanent stiffness of the hip and it is unwise to attempt it. Skeletal traction with 30-40 lbs. weight applied to a pin or wire through the tibia is sometimes successful. The maximum weight should be continued for a month after reduction is obtained and then it may be reduced to a few pounds until the X-rays show satisfactory healing. Or alternatively reduction may be retained with certainty by introducing a tri-fin nail.



FIG 118 Adolescent Coxa Vara with gross displacement

When skeletal traction fails to reduce the displacement within a week or so, operative correction is desirable. The adduction deformity, if left uncorrected, causes considerable disability because of the compensatory apparent shortening; and in addition, the head of the femur is rotated into an unnatural position in the acetabulum so that the joint surfaces are no longer congruous and osteoarthritis quickly develops. There are three alternatives; the head may be replaced in its correct position by osteotomy at the site of displacement, or its alignment can be corrected by trans-cervical osteotomy, or by sub-trochanteric osteotomy. The operation usually performed in Great Britain is sub-trochanteric osteotomy, but a number of surgeons in the United States prefer one of the other alternatives. Whichever is selected, it should be carried out as soon as possible to prevent reactive changes in the joint.

STAGE 3. Reduction is clearly impossible, and if there is considerable adduction deformity, it should be corrected by sub-trochanteric or trans-cervical osteotomy. Arthroplasty or arthrodesis may be necessary, even in young people, if the deformity has been left uncorrected and osteo-arthritis has developed (p. 151).

PAIN. This is nearly always a prominent feature. The amount of pain is not proportionate to the extent of the X-ray changes but depends chiefly on involvement of the periarticular soft tissues. At first there is often no more than aching of the joint after work, and it disappears with a night's rest only to return next evening; it increases slowly in intensity over a period of years. The characteristic pain is worse on movement and after exercise; rest relieves it, but after resting for a time the joint gets stiff and pain is again felt on commencing to move. When the range of movements is small, each movement is made with caution to avoid pain. On examination, pain is produced by passive movements forced beyond the easy range, and there is tenderness to pressure over the joint.

Backache is often severe. It is due partly to the strain on the lumbar spine, itself possibly arthritic and stiff, which has to bend excessively when sitting with a stiff hip, and it is due partly to the position of lordosis which is necessary to compensate for a fixed flexion deformity of the hip.

Pain in bed at night may be very distressing. When there is fixed deformity it is difficult to find a position that gives support to both back and legs. It is hard to get to sleep because when the muscles relax, the joint moves; and during sleep any involuntary movement starts the pain again. The pain is often increased by warmth during the phase when there are active changes in the bone.



FIG 120 Osteoarthritis of the left hip

STIFFNESS AND DEFORMITY. Movements slowly become more and more restricted; at first a patient may find it difficult to make certain habitual movements such as taking a long step, or sitting astride a horse, but as the disease advances, the typical deformity develops and the hip [illegible] external rotation (Fig. 120). When [illegible] dosis, provided the back is not too [illegible] adduction causes apparent shortening which may prevent the foot touching the ground unless the other knee is bent. Real shortening may amount to one inch or more.

X-rays. The appearance varies with the ætiology because osteo- [illegible] existing condition. The [illegible] er weight-bearing area, [illegible] bone become [illegible] the articular [illegible] er sometimes being the earliest change, and new bone formation may continue until eventually the osteophytes reach massive proportions. Small, cyst-like

in the archives of Stockholm hospitals; he was able to trace eighteen of them many years later and by that time all had developed gross osteoarthritis. Shallow acetabulum of lesser degree may also be the precursor of osteoarthritis even though comparatively little of the head of the femur, which is often more globular than usual, is outside the acetabulum (Fig. 119).

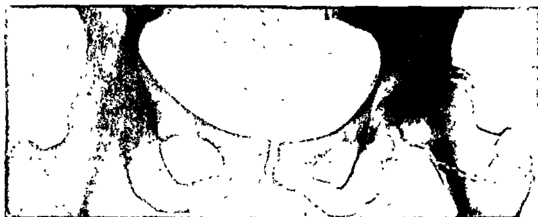


FIG 119 Osteoarthritis The acetabulæ are rather shallow and the femoral heads globular in shape

## Pathology

The articular cartilage is eroded and destroyed, and the underlying bone becomes eburnated. [illegible] often appear in the bone; [illegible] changes which may be either primary or secondary to the arthritic process. The head of the femur tends to enlarge at its periphery, the acetabulum enlarging also in adaptation. Sometimes bone is absorbed at the upper part of the acetabulum where pressure is greatest and the acetabulum "wanders" upwards; sometimes the head becomes flattened and mushroom-shaped to an extent that causes subluxation. Hypertrophic outgrowths of bone occur at the margins of the articular cartilage of both acetabulum and head of femur; this varies in extent and may amount only to "lipping," or large irregular masses may be formed.

The joint capsule sometimes, but not always, is greatly thickened, particularly at its anterior and upper portions. It is then little more than a mass of scar tissue which by its contraction materially assists in the production of deformity. Thickening of the capsule and synovial hypertrophy are important factors in the causation of pain which is more directly related to soft tissue than to bony changes. The synovial membrane around osteophytes usually is thickened, inflamed and tender.

## Clinical Features

The symptoms are pain, stiffness and deformity but the order of appearance varies from patient to patient. One may complain of severe pain and yet have nearly normal movements; another has gross deformity with but little pain and complains only of difficulty with some special movement like getting up from a low chair; the next may be worried chiefly because *"the leg is getting short."*

treatment and major operative procedures. In young or middle-aged people operation may be advised as soon as symptoms become really troublesome, but with the elderly the trend of British practice is to persevere with conservative treatment for as long as possible. It is nearly always possible to relieve severe pain somehow and few patients have to be rejected as untreatable.

**Physiotherapy.** (Chapter XII.) This is useful early in the disease before there is great restriction of movement, but its effect is not permanent. In advanced disease it may reduce muscle spasm temporarily and provide some hours of comparative ease.

**Manipulation.** The range of movement may be improved in early cases. Manipulation is carried out under general anæsthesia; considerable pressure is applied gradually and steadily, but there is danger of fracturing the femur if too great a leverage is used. Weight-traction applied for a week or two before manipulation is valuable.

**Caliper.** This may give relief if pain is felt chiefly when walking. It is not always well tolerated and should not be pressed on an unwilling patient, or on one who is infirm for other reasons than his hip. The caliper should be weight-relieving, preferably with a moulded-leather "bucket" top, and a knee hinge is fitted for convenience when sitting (Fig. 122).

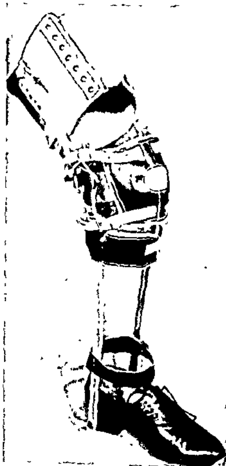


FIG 122 Weight-relieving caliper with "bucket" top and knee hinge and lock

**Joint Acidification.** See p. 403.

**Denervation.** Complete interruption of the sensory nerve supply of a joint would clearly rid the patient of pain originating at the joint. The nerve supply of the hip is derived from too many sources for complete denervation to be practicable, but section of the obturator nerve gives some relief to a proportion of patients. This procedure not only reduces the sensory supply of the hip, but it also diminishes adductor spasm. The intrapelvic portion of the obturator nerve is readily accessible (p. 470), and it may be worth while to try the effect of dividing it when other operative measures are contra-indicated.

**Arthrodesis.** Fixation of the joint by operation eliminates all movement from the hip and therefore all pain. It is the most certain method of relieving pain when only one hip is involved, but it is usually contra-indicated in bilateral affections—function with one stiff hip is good, but with two stiff hips it is deplorable. Arthrodesis, therefore, should not be

spaces often appear in the head or upper part of the acetabulum, sometimes very early, but sometimes later in the course of the disease (*Fig.* 309, p. 400).

## Treatment

Investigation and treatment follow the lines of osteoarthritis in general (p. 102). Local treatment is directed to the relief of symptoms, chiefly pain. Elderly patients are usually less concerned with stiffness and deformity than with pain, and the latter may make life so intolerable that they willingly submit to any procedure that offers relief.



FIG 121 Severe osteoarthritis of the hips in a woman aged 58 years

Pain is not caused by erosion of
the joint; it is caused by the inflam
brane and joint capsule and is asso
troublesome when movements are restricted because the smaller the amount of movement required to cause pain, the more frequently it occurs; the worst pain may be in a joint that has no obvious movement. Treatment may be directed either towards increasing the range of movement sufficiently to enable ordinary movements to be made without pain, or towards abolishing movement entirely. The following methods are available:—

*Physiotherapy.*
*Manipulation.*
*Walking caliper.*
*Joint acidification.*
*Denervation.*
*Operation*—Arthrodesis.
Arthroplasty.
Capsulectomy.
Osteotomy.

The selection of method is based on the severity of the symptoms, the age and condition of the patient, and whether one or both hips are involved. There is no satisfactory half-way measure between palliative conservative

adjacent portions of the acetabulum and head of femur in one or two places and packed with cancellous bone.

Plaster fixation is unnecessary after this operation. The graft consists of cancellous bone which unites very quickly and walking is commenced after six weeks—the tri-fin nail provides the strength, whilst the graft secures rigidity and prevents the pin getting loose. The operation is specially suitable for elderly patients because it greatly reduces the period of post-operative recumbency, and because there is little operative shock since it is unnecessary to dislocate the head of the femur. It is, however, only practicable when there is little deformity, or when it is desirable to

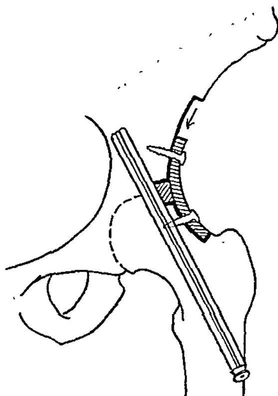


FIG. 124. Arthrodesis of hip sliding graft and fixation by tri-fin nail.

accept the existing deformity because of the patient's age and general condition.

4. INTERNAL FIXATION ONLY. When the patient is not fit for a more radical operation a long nail can be introduced with X-ray control without opening the joint. This does not allow correction of deformity, but it entails little shock and only a few days in bed. Unfortunately, the relief from pain is but temporary because the nail becomes loose and permits sufficient movement to cause a return of pain.

**Arthroplasty.** A successful arthroplasty gives a good range of painless movement and a stable joint, but this is achieved only after months of conscientious work by the patient (Fig. 126). The results are not certain—some are brilliant, but others are indifferent. The operation is indicated especially in bilateral osteoarthritis; it is less successful in rheumatoid

performed in young patients when the other hip, even if symptomless, shows radiological changes.

The main disadvantage of arthrodesis, even when the other hip is normal, is that the loss of movement interferes with sitting; this increases the strain on the lumbar spine and may eventually cause severe pain in the back, especially when there is already some spinal arthritis. When the disease has already caused almost complete loss of movement at the hip, arthrodesis can, however, be performed without increasing the strain on the spine.

Several methods of arthrodesis are available and there are few patients whose physical condition will not permit one of them when performed in modern conditions with all the aids to surgery that are now available.

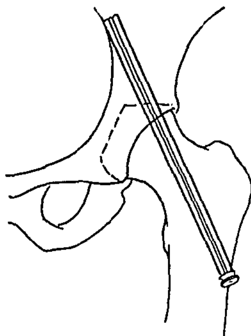


FIG 123 Arthrodesis of hip excision of joint and fixation by tri-fin nail

1. SIMPLE EXCISION. The articular cartilage is removed from the head of the femur and acetabulum. After operation fixation in a plaster spica which includes both legs is necessary for four to six months, and even then fusion is uncertain.

2. EXCISION PLUS INTERNAL FIXATION. Removal of the articular cartilage is combined with internal fixation with a long tri-fin nail (Fig. 123). Post-operative fixation in plaster is necessary for about four months or the pin may become loose and fusion is delayed or prevented.

3. SLIDING GRAFT (Fig. 124). The author uses a long tri-fin nail which is first introduced under X-ray control. The outer aspect of the hip joint is then exposed and the cortical bone removed from the upper surface of the neck of the femur and the exposed part of the head. A graft 3 inches by $1\frac{1}{2}$ inches is cut from the curved outer table of the ilium immediately above the acetabulum and moved downwards so that it overlaps the neck of femur; it is fastened in position with two screws. Slots are cut in





Fig 126 A man aged 52 ...
knee) Eighteen months a
and he is able to raise h

arthritis because of the tendency to reform fibrous tissue. Patients for arthroplasty must be selected with care because good results are improbable unless they are tolerant of the long period of rehabilitation and give full co-operation during after-treatment.

Much ingenuity has been devoted to devising methods of arthroplasty —their number is an indication of the difficulty. The most successful is *Smith-Petersen's* operation which makes use of a vitallium cup to "re-bush" the joint. Vitallium is a non-electrolytic metal that remains inert in the body without stimulating fibrous tissue formation as other metals do. The acetabulum and head of femur are trimmed to an appropriate shape and the cup placed between them. The cup is not fixed in any way and movement takes place on both sides of it, i.e. between the head of the femur and the cup, and *between the cup and the acetabulum. After-treatment is prolonged and* necessitates six to twelve weeks in bed whilst active exercises are carried out, and then about three months walking with crutches or wearing a weight-relieving caliper. Physiotherapy may be desirable for as long as two years.

**Capsulectomy.** This is of value in bilateral disease when arthroplasty is contra-indicated for other reasons. It is often followed by a striking diminution in pain but the effect is unlikely to be permanent. The stability *of the joint is not seriously reduced provided the acetabulum is of normal* depth, but there is some risk if the acetabulum is very shallow and there is commencing subluxation.

It is usually sufficient to excise the upper and anterior parts of the capsule which can be reached through an anterior incision. The anterior lip of the acetabulum, if hypertrophied, may be removed at the same time (*actebuloplasty*). Occasionally it is desirable to excise also the posterior capsule for which a separate, posterior incision is required. After capsulectomy the leg is placed for a few weeks in a Thomas's splint with weight traction; exercises are commenced at once.

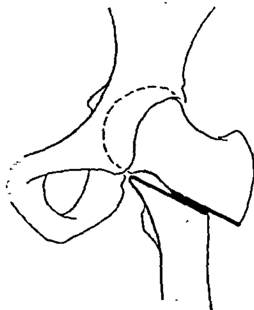


Fig 125 Subtrochanteric osteotomy (McMurray)

**Osteotomy** (*McMurray*). This operation is designed to correct deformity and change the weight-bearing area of the joint. There is little operative shock and movement is retained at the hip, but it entails prolonged and irksome post-operative fixation. The femur is divided obliquely inwards and upwards at such a level that the apex of the distal fragment can be displaced inwards towards the lower border of the acetabulum (Fig. 125). The limb is fixed in a plaster-of-Paris spica until union has occurred, about fourteen to sixteen weeks.

## Ischial Bursitis

(*Synonym*) Weaver's Bottom

The bursa lying between the gluteus maximus and the ischial tuberosity may, as the colloquial name implies, become chronically inflamed as the result of overuse. If necessary it can be excised, but the operation is not to be lightly undertaken because the ramifications of the bursa are often extensive.

## Ilio-Psoas Bursitis

This bursa lies between the tendon of the ilio-psoas, the capsule of the hip and the lesser trochanter. Inflammation is uncommon and diagnosis rather difficult. The patient complains of pain in the groin after exercise; it is caused particularly by movements like crossing the legs when sitting, and sometimes it is very severe. On examination, there is tenderness to deep pressure over the lesser trochanter and in the adductor region, and there is pain on abduction and external rotation of the hip. The bursa occasionally becomes distended to such a size as to cause a swelling in Scarpa's triangle. Symptoms usually disappear with rest aided by short-wave diathermy. Excision involves a deep and difficult dissection in the groin.

Tuberculous infection sometimes takes place by spread from the hip and does not require separate treatment.

## Snapping Hip

There is an audible and palpable "snap" on making a particular movement, usually internal rotation of the partly flexed hip. The condition is sometimes bilateral. The snap is caused by a thick band of fascia lying deep to the anterior border of the gluteus maximus slipping across the great trochanter. It does not occur on passive movement when the muscles are relaxed.

The accomplishment is a habit that is regarded by some of its possessors merely as a parlour trick; in others it amounts to a "tic" and becomes a nuisance. It seldom causes pain but, if indulged in frequently, the fascia or an underlying bursa may become inflamed. Treatment is required when the patient is worried by the snap: the band of fascia is divided and sewn back on itself, preferably under local anæsthesia so that the diagnosis can be confirmed during operation.

## Clicking Hip

This is probably a vacuum click similar to that which some people can produce in their knuckles by pulling the fingers. Distraction increases the potential joint space until the suction of the vacuum is great enough to overcome the resistance of the capsule which then clicks back suddenly against the bone. The movement which causes a click at the hip varies with the individual but it is often extension and external rotation. It sometimes occurs in infants, but usually on flexion and adduction.

## CONDITIONS AROUND THE HIP

### Gluteal Bursitis

There is a large multilocular bursa lying between the gluteus maximus and the great trochanter, and processes often extend between the other gluteal muscles. There may also be a separate subcutaneous bursa over the great trochanter. These bursæ occasionally become chronically inflamed, sometimes as the result of repeated occupational trauma as in coal-mining.

**Tuberculous Infection.** Koch's infection of the gluteal bursa is fairly common. It is not usually associated with other bone and joint tuberculosis, or with active phthisis. The infected bursa forms a tender swelling on the outer side of the hip. There is little disability and the chief complaint is of a constant ache made worse by exercise. Radiographs often show erosion of the outer surface of the great trochanter which has a flattened appearance that is typical of this condition (Fig 127). The erosion



FIG 127 Tuberculous bursitis

is caused at first by intermittent pressure transmitted by the fluid bursa from the contracting gluteus maximus, but later there may be tuberculous involvement of the bone. Sinus formation occurs in neglected cases.

TREATMENT. The bursa and all infected bone should be excised. Local recurrence is unusual. Complete general investigation is of course essential, and if necessary general treatment, as for surgical tuberculosis elsewhere, must be instituted.

an accurate diagnosis is important from the point of view of therapy. Many knees have been irreparably damaged as the result of careless diagnosis and incorrect treatment. "*Internal derangement of the knee*" is a term in common use, but it is not a diagnosis; it is merely a statement that something is wrong inside the joint, and to be satisfied with this is to ask for trouble. The diagnosis is reached by consideration of all the available evidence—history, symptoms, physical signs and X-rays.

The first essential is to establish the nature and direction of the violence. Precise details of the accident are necessary; it is no use jumping to the conclusion that there is a torn cartilage because the injury occurred at football. The direction of the violence determines the nature of the injury and this plays so important a part in the differential diagnosis of a difficult case that it forms the basis of the following classification under which injuries are discussed.

| | |
|---|---|
| 1. *Lateral strain.* | Lateral ligament injury. |
| 2. *Rotation strain.* | (*a*) Coronary ligament injury. |
| | (*b*) Semilunar cartilage injury. |
| 3. *Hyperextension strain.* | (*a*) Anterior cruciate ligament injury. |
| | (*b*) Avulsion of the tibial spine. |
| 4. *Direct violence.* | (*a*) Bruise. |
| | (*b*) Injury to articular cartilage or bone. |
| 5. *Chondromalacia patellæ.* | |
| 6. *Chronic knee strain.* | |
| 7. *Ruptured muscles.* | |

## Examination

The patient is examined lying on a couch in preference to sitting on a chair because muscular relaxation is more readily obtained. The trousers should be taken right off, not just pulled above the knee, so that the condition of the muscles can be seen.

**Movements.** The range of active movements is noted before examining passive movements; it is important to detect the smallest limitation of movement on one side as compared with the other. When pain is caused the patient should be asked to point out exactly where it is felt.

EXTENSION. Slight limitation is easily overlooked unless special care is taken. The foot is lifted from the couch with one hand and the knee partly flexed with the other; then, whilst the muscles are fully relaxed, the knee is allowed to drop straight by its own weight. If there is any limitation of extension, there is not the same "clean" feeling as with a normal knee.

FLEXION. When there is an effusion into the joint limitation, of flexion may be due to the mechanical effect of this.

ROTATION is often overlooked although limitation of rotation with pain referred to the site of injury is common. It is tested by rotating the

## CHAPTER V

# THE KNEE

Disabilities of the knee are grouped here under the heading of the most prominent feature regardless of the pathology in the hope that this arrangement will facilitate diagnosis. There is of necessity some overlap: for example, injuries of the internal semilunar cartilage find their place naturally under "trauma" although they are the commonest cause of locking; but there is no difficulty with the diagnosis of a cartilage tear in the presence of locking, only in its absence when it may be hard to distinguish it from other results trauma.

The following main headings are used :—

*Trauma :*
- *Lateral strain.*
- *Rotation strain.*
- *Hyperextension strain.*
- *Direct violence.*
- *Chondromalacia patellæ.*
- *Chronic knee strain.*
- *Ruptured muscles.*

*Locking.*
*Chronic pain and swelling.*
*Swellings around the knee.*
*Clicking knees.*

## TRAUMA

Joints depend for their stability primarily on the muscles surrounding them, and secondarily on the ligaments. The muscles absorb the shock of violence tending to distort the joint and strain falls on the ligaments only when the muscles are unable to control the violence, or when they are caught "off their guard." The arrangement of the muscles controlling the knee is such that when the joint is extended, or nearly extended, the leverage is small and their protective power is minimal. In no position have they any considerable control over lateral bending or rotation ; for this reason, and because it is so exposed to violence, the knee is particularly liable to injury.

The knee is a complex structure and therefore is subject to many and various injuries. The signs and symptoms often are not distinctive, yet

an accurate diagnosis is important from the point of view of therapy. Many knees have been irreparably damaged as the result of careless diagnosis and incorrect treatment. "Internal derangement of the knee" is a term in common use, but it is not a diagnosis; it is merely a statement that something is wrong inside the joint, and to be satisfied with this is to ask for trouble. The diagnosis is reached by consideration of all the available evidence—history, symptoms, physical signs and X-rays.

The first essential is to establish the nature and direction of the violence. Precise details of the accident are necessary; it is no use jumping to the conclusion that there is a torn cartilage because the injury occurred at football. The direction of the violence determines the nature of the injury and this plays so important a part in the differential diagnosis of a difficult case that it forms the basis of the following classification under which injuries are discussed.

| | |
|---|---|
| 1. *Lateral strain.*. | Lateral ligament injury. |
| 2. *Rotation strain.* | (*a*) Coronary ligament injury. |
| | (*b*) Semilunar cartilage injury. |
| 3. *Hyperextension strain.* | (*a*) Anterior cruciate ligament injury. |
| | (*b*) Avulsion of the tibial spine. |
| 4. *Direct violence.* | (*a*) Bruise. |
| | (*b*) Injury to articular cartilage or bone. |

5. *Chondromalacia patellæ.*
6. *Chronic knee strain.*
7. *Ruptured muscles.*

## Examination

The patient is examined lying on a couch in preference to sitting on a chair because muscular relaxation is more readily obtained. The trousers should be taken right off, not just pulled above the knee, so that the condition of the muscles can be seen.

**Movements.** The range of active movements is noted before examining passive movements; it is important to detect the smallest limitation of movement on one side as compared with the other. When pain is caused the patient should be asked to point out exactly where it is felt.

Extension. Slight limitation is easily overlooked unless special care is taken. The foot is lifted from the couch with one hand and the knee partly flexed with the other; then, whilst the muscles are fully relaxed, the knee is allowed to drop straight by its own weight. If there is any limitation of extension, there is not the same "clean" feeling as with a normal knee.

Flexion. When there is an effusion into the joint limitation, of flexion may be due to the mechanical effect of this.

Rotation is often overlooked although limitation of rotation with pain referred to the site of injury is common. It is tested by rotating the

leg with the knee partly flexed; the normal movement is about ten degrees in each direction.

THE LATERAL LIGAMENTS are examined for laxity by abducting and adducting the extended knee.

CRUCIATE LIGAMENTS. Stability is tested with the knee partly bent; the patient either sits on a chair with the foot resting on the ground, or he lies supine with the knee flexed and the sole of the foot flat on the couch.



FIG 128 Examining for laxity of the cruciate ligaments

The head of the tibia is grasped with both hands and moved backwards and forwards whilst the thumbs exert counter pressure on the condyles of the femur (Fig. 128). Complete muscular relaxation is essential. There is normally an appreciable amount of antero-posterior movement; it is increased in an anterior direction when the anterior cruciate ligament is ruptured, and in a posterior direction when the posterior cruciate is damaged.

**Effusion.** The presence of a small quantity of fluid in the joint may be detected by compressing the suprapatellar pouch from above down so as to force the fluid into the retropatellar region. If there is enough fluid to lift the patella away from the condyles of the femur, the patella can be pushed back against them with a palpable tap known as a "patellar tap."

**Tenderness.** The site of pain and tenderness must be determined with accuracy. It is particularly important to distinguish between tenderness in the line of the joint and at the insertion of the lateral ligaments (Fig. 129).

**Wasting.** The quadriceps muscles waste very quickly when there is any organic disorder of the knee. Wasting is more rapid than might be expected from disuse alone and is probably a reflex phenomenon. It is often most obvious in the vastus internus muscle. Loss of tone can be felt before

any wasting is visible and then the muscles, when gently kneaded, have a softer, less resilient feeling than on the normal side.

**X-Rays.** These are required after all but the most trivial injuries to exclude bony injury, the presence of radio-opaque loose bodies and the rarer diseases.

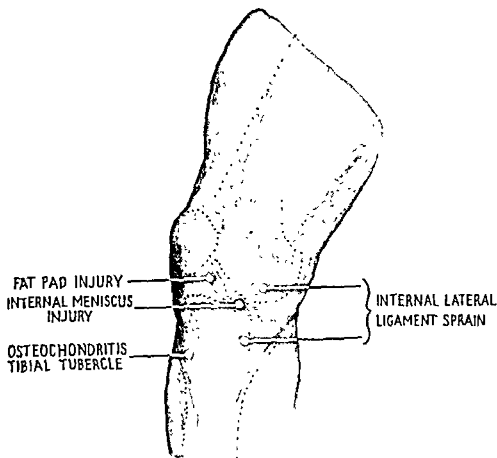



FIG 129 Points of tenderness at the inner side of the knee

## LATERAL STRAIN

Forcible lateral bending results in damage to the lateral ligament on the side opposite to the application of pressure. The knee is more exposed to abduction than to adduction strains, and therefore the internal lateral ligament is injured more frequently than the external.

### Internal Lateral Ligament

The internal lateral ligament is shaped like a broad strap and is attached above to the internal epicondyle of the femur distal to the adductor tubercle, and below to the internal condyle of the tibia (Plate II). It consists of two layers: the superficial layer is a continuation of the deep fascia of the thigh; the deep layer is continuous with the joint capsule and its inner surface is attached to the rim of the internal semilunar cartilage. The ligament is injured by abduction strains; it usually gives way close to the upper or femoral insertion, and less frequently at

the lower insertion. The extent of the damage varies from a minor sprain in which a few fibres are torn, to rupture of the whole ligament.

**Sprain.** The internal lateral ligament may be sprained as the result of a blow on the outer side of the knee, specially in football, and also in such accidents as occur in ski-ing when the knee is suddenly and forcibly abducted. On examination shortly after injury there may be some fluid in the joint, the point of maximum tenderness is on the inner side of the knee about one inch above the joint line, there is usually some limitation of extension, and if there is much effusion, of flexion also. Pain is caused by forcing these movements and by abducting the knee. There is no lateral instability unless the whole ligament is ruptured.

TREATMENT follows the usual lines of that for a sprain. After a minor injury the knee is strapped at once with elastoplast and normal activities need not be restricted; the strapping should extend from mid-thigh to mid-calf, and it should be applied as soon as possible to limit the size of the effusion. After a more severe injury causing marked pain and swelling, a few days' rest from weight-bearing may be necessary, but it is most important for active use to be resumed as soon as possible. The strapping is, therefore, applied over a layer of lint and removed daily for treatment. This consists at first of massage, faradic stimulation and careful active and passive movements; the range of movements is quickly increased and the muscles are prevented from wasting by graduated exercises. A player with a moderately severe sprain should be able to start training with knee strapped after a week, and return to first-class football after two or three weeks.

**Chronic Sprain.** In the absence of effective treatment, the resulting scar in the ligament may cause chronic symptoms. The knee feels weak and is painful to use; there is tenderness at one of the insertions of the ligament, pain on passive abduction and perhaps slight limitation of flexion and extension. Sometimes there is a history of the knee "giving way" that may be mistaken for a cartilage injury. An injection of novocain into the tender spot, repeated once or twice if necessary, often gives relief, but manipulation under an anæsthetic may be required (p. 181).

**Complete Rupture.** This is a serious injury but fortunately it is not very common. Diagnosis is not as a rule difficult. The patient walks guardedly, if at all, and complains that the knee gives way inwards; there is swelling and tenderness, and a gap may be palpable in the ligament; effusion of blood or fluid into the joint is not great because it escapes through the gap into the subcutaneous tissues. The pathognomonic sign is lateral instability but when the pain is severe it may only be possible to elicit it under an anæsthetic. The anterior cruciate ligament may be ruptured at the same time as the lateral ligament and therefore evidence of antero-posterior instability should also be sought.

TREATMENT. *Severe Injuries.* The ligament and joint capsule should be repaired at operation without delay. The indication for operation is gross lateral instability.

In the absence of treatment there may be considerable instability of the

joint causing serious disability. Satisfactory end to end suture of the ligament is not possible at a late stage but stability is greatly improved by using the semitendinosus tendon as re-inforcement. The tendon is implanted into bone at the upper and lower insertions of the ligament and the remains of the ligament are wrapped around the tendon and stitched firmly to it.

*Moderately Severe Injuries* may be treated conservatively but the knee must be protected from strain for a considerable time. If there is marked hæmarthrosis, the blood is aspirated and then a pressure bandage is applied to prevent further swelling—a real pressure bandage over a voluminous layer of wool extending the length of the leg. This is kept on for a few days and weight-bearing is avoided. Walking is then permitted with the knee protected by a plaster sleeve extending from above the ankle to the top of the thigh (Fig. 130); the knee should be slightly flexed and a cuff of zinc oxide felt plaster is placed round the ankle to prevent the plaster slipping down and chafing the skin over the tendo-Achillis. It is an advantage to cut a window in the plaster in front of the thigh through which the quadriceps can be given faradic stimulation. The plaster gives adequate fixation whilst preventing unnecessary deterioration of the muscles. It should be worn for about four weeks and then bivalved to permit daily removal for massage, active exercises, etc.

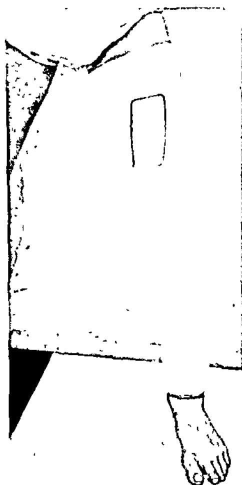


Fig 130

The results of treatment are fairly good provided it is begun early and continued for a long time. There may be some permanent laxity of the ligament; stability then depends on the tone of the muscles and therefore treatment must be continued until there is full muscular recovery.

**Pelegrini-Steida's Disease.** This is a fairly common condition in which a plaque of new bone is formed over the internal condyle of the femur, usually rather high up (Fig. 131). It may occur in association with internal lateral ligament injuries but more frequently it is due to direct violence and it should be suspected with crush injuries which are unduly slow in resolving. The few cases that come to operation suggest that the ossification occurs in an organised hæmatoma superficial to the internal lateral ligament. Antero-posterior X-rays show a distinct gap between the plaque of bone and the femur, but in two patients I have operated on

the lower insertion. The extent of the damage varies from a minor sprain in which a few fibres are torn, to rupture of the whole ligament.

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In the absence of treatment there may be considerable instability of the

relaxed on flexion. The biceps and the ilio-tibial band reinforce it to some extent and protect it from strain.

Injuries of the external lateral ligament are caused by adduction strains and are less common than injuries of the internal ligament. The ligament may be damaged at either point of insertion but the lower is the commoner. Sometimes, instead of the ligament itself being injured, a fragment of the head of the fibula is avulsed. Diagnosis depends on the presence of pain and tenderness at one end of the ligament, and pain on passive adduction. Lateral instability can be demonstrated when there is complete rupture.

Treatment is similar to that for injury of the internal lateral ligament. Complete rupture is not, however, so serious because the ligament is well reinforced by the surrounding structures. A prolonged period of fixation may therefore be unnecessary, and operative repair is but seldom required.

## ROTATION STRAIN

Forcible rotation of the knee may injure one of the semilunar cartilages, or the coronary ligaments which attach them to the head of the tibia. It is seldom that either of these structures is damaged unless there is rotatory movement, but occasionally the coronary ligament is bruised by a direct blow.

### The Coronary Ligaments

The coronary ligaments are delicate structures which attach the periphery of the semilunar cartilages to the tuberosities of the tibia. They are only a few millimetres in length, those in association with the internal cartilage being shorter than the external. The internal cartilage has, therefore, a smaller range of movement and the internal coronary ligament is put on the stretch and torn more easily than the external (Plate II).

Injury results from the same type of accident as semilunar cartilage injuries, a twist of the flexed knee ; but whereas it is necessary for the leg to be bearing weight for the cartilage to be injured, the coronary ligament can be damaged whether it is weight-bearing or not.

The symptoms are pain and tenderness in the joint line on the inner side of the knee. There is usually an effusion into the joint and extension is slightly limited by muscle spasm. True locking never occurs. There may be difficulty in distinguishing coronary ligament strain from a cartilage injury because the site of maximum tenderness is very similar, and limitation of extension can be mistaken for locking. The differential diagnosis is considered on p. 169.

Treatment is as for sprain of the internal lateral ligament but the symptoms are seldom sufficiently severe to require rest in bed. Manipulation during the acute stage is contra-indicated. Most injuries recover in about a fortnight, but some fail to resolve completely and the symptoms become chronic. The patient then complains that the knee is weak and painful and "lets him down" unexpectedly, but there is never true locking or even the sensation of something slipping inside the knee that is so often

the upper pole of the plaque joined the femur at the insertion of the adductor magnus, whilst the lower pole tailed off into fibrous tissue which blended with the lateral ligament.

The condition is frequently mistaken for a sprain of the upper insertion of internal lateral ligament because it follows injury, and because there is pain on the inner side of the knee and limitation of movement. The tenderness, however, is at a higher point than with a sprain, the symptoms



Fig 131. Pelegrini-Steida's disease

are more persistent and the X-ray appearance is characteristic. If detected early when there is but little ossification, progress may be prevented by protecting the knee from movement with a plaster sleeve (Fig. 130). Static quadriceps exercises should be given whilst in plaster but movement is not commenced until the active process of ossification is complete, a matter of some weeks. Operation at an early stage is not successful, but on the rare occasions when symptoms persist after the condition has become stationary, they may be relieved by removal of the new bone.

## External Lateral Ligament

The external lateral ligament is a strong cord attached above to the external condyle of the femur just proximal to the groove for the tendon of the popliteus, and below to the head of the fibula. It is in close relation to the tendon of the biceps femoris which divides into two portions to embrace it. The ligament becomes taut on extension of the knee and is



The Right Knee (semi-diagrammatic)

[To face page 166

experienced with a torn cartilage; on examination there is tenderness, limitation of extension and perhaps wasting of the quadriceps. During the chronic stage manipulation is of great value; under an anæsthetic the knee is moved through its full range with particular attention to extension and rotation. Manipulation is followed by physiotherapy which must be continued until the wasted muscles are fully restored.

## The Internal Semilunar Cartilage

The semilunar cartilages are two concentric fibro-cartilages that lie between the head of the tibia and the condyles of the femur (Plate II). The internal cartilage is nearly semi-circular; it is attached by its two horns to the intercondyloid fossæ of the tibia, and at its margin to the capsule of the joint and the deep layer of the internal lateral ligament which is blended with the capsule. The coronary ligament arises from the middle third of the inferior border of the margin of the semilunar cartilage and passes downwards and forwards to be attached to the rim of the tuberosity of the tibia. The synovial membrane blends with the peripheral attachments of the semilunar cartilages but does not cover their weight-bearing surfaces.

The function of the semilunar cartilages is apparently concerned with lubrication of the joint. The lubrication of any bearing requires the formation of a liquid film between the moving surfaces, and it is most efficient when the surfaces are inclined to each other at a small angle; also, in a bearing like the knee which has a reversible action, provision has to be made to reverse the inclination of the surfaces. The semilunar cartilages are so arranged as to reduce the angle of apposition of the joint surfaces and provide a reversible action. Removal of a semilunar cartilage reduces the efficiency of lubrication of the knee but not, as far as can be told, to an extent that interferes with function or reduces the life of the joint.

**Pathology.** Accounts of the mechanism of cartilage injuries vary considerably but all have one point in common—the injury is caused by rotation of the leg whilst it is partly flexed and bearing weight. A good description, although a simplified one, is given by Bristow. He says "The primary injury to the cartilage is a longitudinal tear or split in the substance of the cartilage, caused by the direct compression or grinding action of the femur on the tibia, with added trauma caused by a rotation force, when the weight is borne on the leg with the knee flexed." Bristow considers that the primary injury is a longitudinal tear which may extend along the whole length of the cartilage or else be confined to its anterior or posterior portion. *The various secondary displacements that may occur are shown in Fig. 132.* The "bucket handle" type is produced when there is a complete tear and the central fragment is displaced inwards to lie between the condyles of the femur.

The question of repair of torn semilunar cartilages is of importance. It is sometimes assumed that healing will occur if the fragments are replaced so that they lie alongside one another in the normal position, but there is no evidence that such repair ever does take place, and there is no report of a cartilage being found at operation with a scar that might be due to an old

tear. Fibro-cartilage is an avascular tissue and it would be surprising if repair did occur. The nearest approach to repair is when the cartilage is avulsed from its peripheral attachment leaving no cartilaginous rim behind, and then it can re-adhere to the capsule because of the good blood supply of the fibro-fatty tissue joining it to the latter. There is also evidence that after complete removal of a semilunar cartilage a new structure may be formed which resembles a cartilage closely in both shape and consistence. This can only happen if the entire cartilage has been excised without leaving a rim of avascular fibro-cartilage attached to the joint capsule. Walmsley and Bruce have shown it to occur in rabbits and dogs, and it has occasionally been observed in humans. The new "cartilage" is composed of fibrous tissue and can be injured in the same way as a normal cartilage.

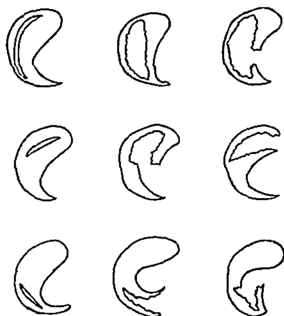


FIG 132 Tears of the internal semilunar cartilage (after Bristow—see p 166)

**History.** PRIMARY INJURY. The internal cartilage may be torn in any circumstances that fulfil the conditions of rotation of the flexed, weight-bearing knee. This may happen in the most unexpected way, for example, when a woman kneeling in front of the grate as she cleans it turns round to reach for something behind her. Coalminers sustain cartilage injuries more frequently than people in other occupations because they work with flexed knees in a confined space. Many cartilage injuries occur at football, but by no means all football injuries to the knee involve the cartilages. A typical history is that of the player who has his weight on the partly flexed knee preparatory to kicking with the other foot when something causes him to loose his balance ; his body swings round but the boot of the standing leg is firmly fixed to the ground and the knee is twisted and injured. Any attempt to move the knee is painful and he finds it impossible to straighten it himself; his friends wrench it straight for him, and although he may be able to finish the game the knee swells a great deal

**Diagnosis.** Injuries of the internal cartilage are commoner in males than females, probably because males are more exposed to trauma. They may occur at any age but they are rare in children and adolescents and the diagnosis should be made only with great caution when the patient is under sixteen years of age.

The history must be taken in detail going back to the primary injury, that is the first occasion on which the knee caused any trouble. It is not enough to be told that the knee was injured some years ago during a game of football; it is necessary to find out exactly what the player was doing, e.g. he was playing on the left wing and about to centre the ball when the right knee gave way under him. This establishes the fact that the right knee was exposed to a force tending to rotate the tibia inwards whilst it was flexed and bearing weight, and therefore the internal semilunar cartilage may have been damaged. But if the right knee was hurt whilst

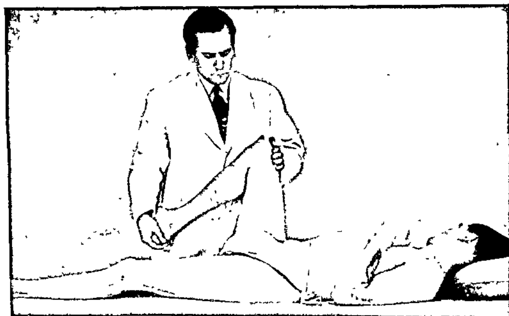


FIG 133 Eliciting McMurray's sign

he was trying to trap the ball with the right foot, the probability is that a rotation force was applied when the knee was not bearing weight and the cartilage is unlikely to have been injured. The primary injury is usually severe enough to be fixed in the patient's memory although occasionally a torn cartilage is found at operation when no history of injury can be obtained.

Ski-ing injuries to the knee seldom result in damage to the semilunar cartilages although such damage is often wrongly diagnosed. A common type of accident is that of the inexpert runner who crosses his skis and falls backwards and outwards when attempting a downhill Christiania swing; the lower knee may be subjected to abduction, flexion and external rotation violence, or the upper knee to adduction, flexion and internal rotation violence. The knees are relieved of the body weight at the time of greatest strain by the centrifugal force of the body falling outwards and the

afterwards. By no means all histories are so clear but a similar mechanism can often be elicited by careful cross-examination.

"Locking of the joint" is a common but not invariable feature. The obstruction is caused by the torn portion of the cartilage being nipped between the femur and the tibia during extension. An anterior tear (Fig. 133) may lock the knee so that the last 30° of extension are prevented, but a "bucket-handle" tear tends to limit only the last few degrees; in both cases flexion is free. Locking seldom occurs when the tear is confined to the posterior portion of the cartilage. Unlocking is of even greater diagnostic importance than locking; there can be no doubt that a mechanical block is present when movement is immediately restored by manipulation and the patient feels a click in the joint as the obstruction is removed.

Subsequent Displacements happen very easily once the primary tear has occurred. They are often produced by rotation but no great violence is necessary; sometimes the knee "goes out" for no apparent reason whilst walking on level ground, and sometimes even whilst asleep in bed. The patient frequently is aware of "something moving inside the joint," an observation of diagnostic value.

**Physical Signs.** Primary Injury. The most constant finding is tenderness in the joint line (Fig. 129); with anterior horn tears the tenderness is chiefly in front of the internal lateral ligament, and with posterior tears behind the ligament. Fluid accumulates rapidly and distension of the joint may become extreme if the displaced cartilage is left unreduced. There is pain on forcing movement, and usually limitation of movement, the latter being due either to muscle spasm which restricts rotation and therefore prevents full extension, or to locking. Locking can only be diagnosed with certainty after the process of unlocking with immediate return of movement.

Subsequent Displacements. The physical signs are similar, but usually less severe. Precise localization of the point of tenderness assists in distinguishing a cartilage injury from a chronic sprain of the internal lateral ligament. Neither effusion nor limitation of movement are constantly present, but with old-standing injuries there is likely to be some wasting of the quadriceps. Occasionally an anterior tag of torn cartilage can be palpated as a lump which comes and goes in the joint line during movement of the knee. Sometimes there are no physical signs and reliance has to be placed entirely on the history.

*McMurray's Sign* is present in many patients. It is elicited as follows: with the patient recumbent and the muscles relaxed, the knee is flexed fully and the lower leg externally rotated and abducted (Fig. 133); the knee is then slowly extended whilst maintaining the rotation and abduction. The loose portion of the cartilage may be caught between the femur and the tibia causing a definite click.

**X-Rays** should always be taken to exclude bony injury or the presence of a loose body in the joint. Air arthrography is still in the experimental stage but it may prove a valuable aid to diagnosis when difficulties in the interpretation of films have been overcome.

There are several methods of manipulation. A simple one is to place the forearm as a wedge underneath the knee and then flex the knee strongly around it. This separates the joint surfaces of the femur and tibia and may allow the displaced portion of the cartilage to slip back into place. Another method is to hold the foot with one hand and the knee with the other; the leg is externally rotated, the knee is abducted to open the joint and then, whilst maintaining the abduction and rotation, the leg is straightened with a jerk. Some displacements are reduced by full flexion of the knee.

The question always arises as to whether or no a torn cartilage should be excised at once. The answer depends to some extent on the occupation and mode of life of the patient. If he is a professional footballer, or a coalminer, or follows any occupation that exposes him to rotation strains, he is almost certain to have further trouble ; the total period of incapacity will be reduced by operating without waiting for re-displacement and before there is serious muscle wasting. On the other hand less active people sometimes go through life without further trouble and they should be given the opportunity to avoid operation by waiting to see if the displacement recurs.

Subsequent Displacements. The treatment of recurring displacement of a meniscus is, without doubt, by operation. The loose fragment is to all intents and purposes a loose body in the joint, and the inevitable sequel of frequently repeated trauma to the articular cartilage is the development of osteoarthritis. The patient should, therefore, be pressed to have the loose semilunar cartilage removed.

Operation must be carried out in ideal conditions with perfect aseptic technique. It is an operation of choice and as such should only be embarked upon when the right conditions are available for the results of misadventure are too tragic to take any unnecessary risk. The entire cartilage should be excised, not only the detached fragment, and this is usually possible through a single anterior incision. If a narrow strip of the posterior part of the rim cannot be removed in this way, it is better to leave it and see if it causes later symptoms, and this happens in only a small percentage of patients, before making an additional posterior incision.

After operation, a pressure bandage is applied and the patient remains in bed for ten days with the dressings undisturbed. During this period flexion is not allowed, but on the second day static contractions of the quadriceps and straight-knee leg raising are commenced. The dressings and stitches are removed on the tenth day, and weight-bearing is permitted. Massage and exercises of increasing strength are given, if possible daily, but the pace must not be forced too rapidly. There may be a small effusion into the joint for a week or two but this absorbs and requires no special treatment. In my experience earlier movement or weight-bearing increases the liability to effusion and retards ultimate recovery. The total time off work varies from two weeks for a clerk, to six or eight weeks for a professional footballer and the latter is often able to play in first class football after this time.

semilunar cartilages are seldom injured, but one or other of the lateral ligaments or the internal coronary ligament are often sprained. During a Telemark turn the weight is on the leading leg and a cartilage may be torn.

The diagnosis of a torn meniscus in a classical case seen soon after injury is straightforward. There is a typical history, the knee is locked in the flexed position and there is tenderness over the inner side of the joint line; manipulation unlocks the knee and immediately restores full extension. Nor does a typical example of recurrent displacement cause difficulty; there is a history of a primary injury followed by repeated slipping felt at the inner side of the knee, and pain and tenderness over the joint line. Locking occurs in less than half of all cartilage injuries, but when it is present the diagnosis is fairly certain because the presence of other types of loose body which may cause locking is excluded by radiography.

The differential diagnosis between recurring displacement of an injured cartilage and a chronic rotation sprain of the coronary ligament is sometimes very difficult. In both conditions the history is similar, and in both there may be tenderness in the joint line, some effusion into the joint and limitation of flexion and extension by muscle spasm. It may be impossible to make a diagnosis immediately, and when there is any doubt the treatment should be as for sprain and the subsequent course observed. If the cartilage is at fault, the knee is likely to return to normal and remain free of signs and symptoms until the next occasion when the torn fragment is displaced. A chronic sprain is liable to exacerbations resembling a recurring cartilage displacement but the knee does not become quite symptom free between attacks. The diagnosis can often be settled by manipulating the knee under an anæsthetic; this usually cures a sprain but it does not prevent the recurrence of cartilage trouble (p. 182).

**Treatment.** PRIMARY INJURY. If the knee is locked, it should be freed as soon as possible by manipulation and then strapped with elastoplast. The effusion reaches a maximum in a few hours and it is an advantage if the strapping can be applied before it has developed. The treatment is then as for sprain. Rest from weight-bearing may be necessary for a day or two but active use is resumed as soon as possible; massage, faradism, and static contractions to maintain the tone of the quadriceps are started on the first day, and after a few days it should be possible to move the knee through its full range. Treatment is continued until the joint is symptomless and the muscles have returned to normal.

It is important to reduce any displacement of the cartilage as soon as practicable. If it is left unreduced and the patient hobbles about on a bent knee, the synovial membrane is irritated, it becomes thickened and inflamed and recovery is greatly delayed. Reduction may be possible without an anæsthetic, especially if attempted immediately after the injury. The muscles have to be caught "off their guard" and this requires a certain amount of knack. The first attempt is the most likely to succeed because manipulation is painful and the patient becomes wary of subsequent efforts; unless the attempt is made very soon after the injury it saves much pain to give an anæsthetic straight away.

extension is reached; and when flexing the joint, it occurs a few degrees before full flexion is reached. The snapping may be caused in one or two ways. In one, a ridge develops on the upper surface of the cartilage, and during movement this ridge travels like a wave along the cartilage in front of the advancing femur until, near the extreme of movement, the femur jumps over it; in the other, the whole cartilage is displaced forwards during extension and the femur slips over its posterior border.



Fig 134 Congenital disc external semilunar cartilage with an oblique split across the centre It was removed from a middle-aged woman who had had no symptoms until she sustained a rotation injury a few months previously

Disc and discoid cartilages are apparently more liable to injury than normal external cartilages, and by the same type of accident. The resulting tear may be longitudinal or transverse, or there may be a split which is oblique in the horizontal plane across the central portion of the cartilage. Many disc cartilages are noiseless and symptomless until after injury and the abnormal shape is discovered for the first time at operation (Fig. 134).

Treatment. In young children the meniscus should be left alone unless it is causing much inconvenience because the symptoms may disappear spontaneously. In adolescents and adults spontaneous recovery is less probable; the meniscus is behaving like a loose body in the joint and therefore it should be removed before it damages the articular cartilage.

## HYPEREXTENSION STRAIN

A hyperextension strain may injure the anterior cruciate ligament or avulse the anterior tibial spine.

The anterior cruciate ligament is attached below to the upper surface of the tibia just in front of the anterior tibial spine, and it passes upwards, backwards and outwards to the posterior part of the inner surface of the external condyle of the femur (Plate II p. 166). The ligament becomes taut during extension of the knee and acts as the pivot around which external rotation takes place during the final movement of extension; together with the posterior capsular ligament it prevents hyperextension.

Injury to the ligament is usually caused by forcible hyperextension. The damage may consist in a tear of a few fibres only, or there may be a complete or nearly complete rupture. Sometimes, instead of being torn, the insertion of the ligament into the head of the tibia is avulsed together with the surrounding portion of bone. The ligament may also be ruptured when the knee is dislocated, and in very violent abduction injuries after the internal lateral ligament has given way.

### The External Semilunar Cartilage

**Injuries.** The external semilunar cartilage is injured less frequently than the internal, the proportion being about one to ten, perhaps for the reason that the longer coronary ligament of the external cartilage allows it greater freedom of movement. The external cartilage is not infrequently injured in older children and adolescents, whereas injury of the internal cartilage is uncommon at this age.

The mechanism of external cartilage injuries is similar to that of the internal, that is rotation of the flexed, weight-bearing knee. The primary injury is frequently less severe, and often there is no history of injury but only a long story of vague trouble. The patient feels the knee to be weak, or has a feeling of insecurity, and he tends to avoid games or occupations that cause rotation strains. He may be aware of something "slipping" on the outer side of the knee; "clicking" on movement is common, but true locking is rare. Pain tends to be rather diffuse, and tenderness may be localized to any point on the outer and posterior aspects of the joint line.

The diagnosis is made largely on the history of "trouble on the outer side of the knee." There are fewer conditions which have to be differentiated than in the case of internal cartilage disorders; external lateral ligament strain is readily distinguished because the points of tenderness are well above or below the joint line, and external coronary ligament strain very rarely occurs. McMurray's sign, elicited by internal rotation and adduction, is often positive (p. 168).

TREATMENT. The cartilage should be excised. The operation and after-treatment are similar to that for removal of the internal cartilage. Manipulation plays little part in the treatment of external cartilage injuries because of the absence of locking. Moreover, since strains of the *coronary ligament do not occur, there are fewer cases of "pseudo-cartilage"* injuries that respond to manipulation.

**Congenital Abnormalities.** The semilunar cartilages are developed from a plate of mesodermal tissue lying between the tibia and the femur; this plate divides into two parts and the central zone of each absorbs to form the typically shaped cartilages. Absorption sometimes fails to occur in the *external* cartilage leaving either a complete disc, or an abnormally broad or "discoid" cartilage (Fig. 134). Cysts of the semilunar cartilages are thought also to be derived from mesodermal remnants (p. 209).

Congenital disc cartilages are not very common, but when present they usually give rise to symptoms sooner or later. Symptoms often begin during childhood or adolescence, usually between six and fourteen years, although the onset may be delayed until adult life when attention is drawn to the abnormality by an injury.

The typical feature is an audible and palpable "thud" or "clunk" during movement. There is seldom any serious disability, but there may be a painful, dragging sensation just before the snap occurs. When the flexed knee is extended, the snap takes place a few degrees before full

impaired. The femur slides backwards and forwards on the tibia making it difficult even to walk and the patient may be prevented from following an active occupation. If his work is mainly sedentary, development of the thigh muscles is likely to give sufficient control of the joint; for more active work a knee cage that prevents all movements except flexion may be prescribed.

Many operations designed to replace the ligament have been tried but none is satisfactory enough for use as a routine measure. Most are modifications of Hey Groves' operation in which a strip of fascia lata still attached at its lower end, or else the semitendinosus, is passed through drill holes in the tibia and femur in such a manner that it crosses the knee in the position normally occupied by the ligament.

## Avulsion Fracture of the Anterior Tibial Spine

This occurs as the result of a hyperextension injury instead of rupture of the anterior cruciate ligament. The diagnosis is revealed by the routine



FIG 135 Avulsion of the anterior tibial spine

radiograph taken in all cases of injury (Fig. 135). The avulsed piece of bone is roughly circular in shape and about an inch in diameter, and it includes part of the articular surfaces of both condyles of the tibia. The anterior horns of both the semilunar cartilages overlap the fragment. The anterior cruciate ligament blends with the anterior horn of the external semilunar cartilage which is therefore lifted up with the fragment. The attachment of the internal semilunar cartilage is not disturbed and the fragment of bone is often displaced above the cartilage; the latter then lies between the fragment and the cavity from which it was torn and may interfere with its replacement.

Trivial displacement causing no limitation of extension should be treated conservatively. Two or three weeks protection from weight-bearing and active exercises to maintain muscle tone may be all that is necessary.

## The Anterior Cruciate Ligament

**Sprain.** There is a history of a hyperextension injury followed by an effusion into the joint. Full extension is limited by pain which the patient describes as being "inside the joint." There is no tenderness at the front and sides of the knee, but there may be tenderness behind it due to associated strain of the posterior capsular ligament. There is no antero-posterior instability, but passive antero-posterior movement causes pain. *X-rays must always be taken to exclude avulsion fracture of the anterior* tibial spine.

The treatment of a sprain in the acute stage is similar to that of any other sprain. The knee should be strapped to control effusion, and used. Massage and active and passive movements are commenced early, and particular care is taken to restore full extension.

Chronic symptoms occur when the injury fails to resolve completely. The knee feels unstable and hurts with any movement involving full extension. On examination there is no tenderness, but passive extension and antero-posterior movement both cause pain which is felt "inside the joint" and cannot be localized accurately. Treatment is by manipulation under anæsthesia followed by physiotherapy (p. 181).

**Complete Rupture,** or nearly complete rupture, of the ligament *produces a severe reaction. The knee is distended with blood, there is* pain on attempting any movement, and tenderness over the joint. When the reaction has subsided abnormal antero-posterior mobility can be demonstrated and this is pathognomonic of the injury (Fig. 128, p. 160).

Complete rupture is fortunately uncommon. Some fibres usually remain intact and when this is so there is a chance that the ligament will reform. All patients should be treated in the first place on this assumption by immobilization. The blood is aspirated and a pressure bandage applied; the patient is kept in bed with the knee slightly flexed over a pillow until the effusion has subsided, and then the knee is immobilized in a plaster cast. The best position for fixation is a matter of doubt. Probably the soundest view is that of McMurray who advises an angle of 40° short of full extension in order to relax the ligament. If this position is adopted, the plaster should extend from groin to toes, and a walking iron is attached to compensate for the apparent shortening due to flexion of the knee. A window is cut in the plaster in front of the thigh through which faradism is given. The plaster is retained for at least three months. After-treatment consists in massage, exercises and faradism, and everything possible must be done to develop muscular power. Manipulation may be necessary to restore full extension.

Conservative treatment on the whole gives good results. The ligament may never regain its previous strength and tautness, but some increase in antero-posterior movement need be no handicap to the patient provided care has been taken to develop the maximum muscular control of the joint.

In neglected injuries, and when the ligament has failed to reform in spite of treatment, the joint may be so unstable that its function is gravely

THE ARTICULAR CARTILAGE of the femur is accessible to direct violence when the knee is flexed; it may be bruised or a small fragment may be broken off. The condition is recognized by accurate localization of the point of maximum tenderness which remains constant when the superficial structures are moved. The injury is of some importance because the symptoms are usually very slow to improve, and pain and weakness, which may persist for months, are often uninfluenced by treatment.

PATELLA. A direct blow on the patella may cause a crack fracture of the patella or damage the articular cartilage of the patella and the femur. Such injuries are accompanied by hæmarthrosis and usually take a very long time to recover.



FIG. 136. Tripartite patella.

*Bipartite Patella* is found in about 1 per cent of people and can easily be mistaken for a fracture. The appearance is due to a congenital anomaly in which the bones ossify from two or more centres instead of the usual one. There are several variations of which the commonest is for the upper and outer angle of the patella to remain separate from the rest of the bone (Fig. 136). The condition is symptomless and is only discovered during X-ray examination made for some other reason.

Treatment. Direct violence injuries in the acute stage are treated as sprains. Hæmarthrosis, if marked, should be aspirated and a pressure bandage applied. Chronic symptoms call for manipulation under an anæsthetic and the joint is moved through its full range, particularly extension and rotation; full movements are afterwards maintained by physiotherapy. Injury to the fat pads is not invariably relieved by manipulation and excision of the affected tissues is very occasionally necessary.

When there is gross displacement of the fragment, the knee is first emptied of blood by aspiration, and then the attempt is made to manipulate the knee into full extension; if this is successful a plaster sleeve is applied (Fig. 130, p. 163).

Manipulative reduction may be impossible when the internal semilunar cartilage is interposed and open reduction is then necessary. Some surgeons prefer open reduction whenever there is a major displacement because it is difficult to be sure that satisfactory reposition has been obtained by manipulation. The fragment of bone is fastened in position with a peg, and the knee is fixed in plaster in 10° of flexion. Quadriceps contractions are commenced at once and weight-bearing is resumed after ten days; the joint should be protected by a plaster sleeve for six weeks.

### Posterior Cruciate Ligament

Rupture of this ligament does not commonly follow hyperextension injuries but it is mentioned here for convenience.

The posterior cruciate ligament is attached below to the posterior intercondyloid fossa of the upper surface of the tibia. It passes upwards, forwards and inwards to its upper insertion into the anterior part of the outer surface of the inner condyle of the femur. The ligament becomes taut on flexion of the knee. It is injured in the more serious type of accident involving dislocation of the knee, particularly posterior dislocation, and the anterior cruciate ligament is often torn at the same time.

The symptoms resemble those of rupture of the anterior cruciate ligament, but the increase in antero-posterior mobility is due to the tibia moving backwards on the femur instead of forwards. Treatment follows exactly the same lines and is always conservative in the first instance. Operation should be reserved for very exceptional cases.

## DIRECT VIOLENCE INJURIES

Direct violence such as a kick may injure any underlying structure, i.e. the joint capsule and ligaments, synovial membrane, retro-patellar fat pads, articular cartilage, or bone. The violence may also cause a sprain of the lateral ligament on the side opposite to the blow which gives rise to symptoms additional to those at the site of the blow. The semilunar cartilages cannot be torn by direct violence.

Soft Tissue injuries due to direct violence are really bruises. The tissues are crushed and there is capillary hæmorrhage into their substance. The symptoms closely resemble those of a sprain—a localized area of tenderness, effusion into the joint and perhaps slight limitation of movement.

The Retro-patellar Fat Pads lie in folds of synovial membrane behind and to each side of the patellar ligament. A kick in this region may cause a small hæmorrhage into the fat pads; occasionally a similar lesion results from a rotation strain. The symptoms resemble those of a sprain but the position of tenderness may lead to a mistaken diagnosis of a tear of the anterior horn of the semilunar cartilage. There is a tendency, especially in older patients, for the symptoms to become chronic.

although each attack only lasts a short while, the symptoms recur after strenuous exercise. When there is a partially detached flake of articular cartilage projecting from the surface of the patella, a "catch" is felt on straightening the knee, but there is no true locking unless a loose body is present. After the synovial membrane has become inflamed pain and swelling are more troublesome, and the periodical exacerbations are slower to subside.

The physical signs are not constant but there is often pain on rubbing the patella transversely across the femur, and sometimes there is tenderness at the margins of the patella, usually at the lower pole. With a careful radiological technique it is possible to show the contour of the articular cartilage and irregularity of the outline can sometimes be demonstrated. At a later stage, radiographs show the typical changes of osteoarthritis involving chiefly the patello-femoral portion of the knee-joint.



FIG 138 Chondromalacia patellæ Pre-operative X-ray of the knee from which the specimen illustrated in Fig 137 was removed

**Treatment.** The natural history of the complaint is not yet known because a sufficient number of proven cases has not been followed for long enough to discover which eventually develop osteoarthritis. However, since chondromalacia in younger life is much commoner than patello-femoral osteoarthritis in older people, it would seem that the treatment in early cases should be conservative. Minor symptoms are usually alleviated by physiotherapy, but immobilization by means of a plaster back-slab is sometimes necessary.

Operation is indicated when there is clinical or radiological evidence of gross destruction of the articular cartilage. The choice of operation is between shaving off the rough and degenerate cartilage, and excision of

## CHONDROMALACIA PATELLÆ

It has long been known to pathologists and operating surgeons that degenerative changes occur in the articular cartilage of the patella with some frequency but systematic descriptions of the condition did not appear in the literature until after 1930, and even now the significance is not fully understood. Pathological changes of this type are very common and post-mortem examination has shown them to be present in as many as 30 per cent of bodies of eighteen to twenty years of age, the figure rising to over 90 per cent in middle life. Acute symptoms, however, are much less common, and although they do sometimes occur in young adults, the knee often causes no trouble until osteoarthritis develops later in life.

The first changes are usually in the central or the lower part of the articular cartilage of the patella (Fig. 137). The cartilage loses its lustre,



FIG 137 Chondromalacia patellæ Photograph of a patella removed from a woman aged 33 who was complaining of chronic pain and swelling of the knee.

œdematous nodules appear on it, and the surface becomes split and raised by fine longitudinal and transverse fissures. Later the cartilage flakes off leaving a deep erosion which often extends to the underlying bone; the detached fragments of cartilage may grow and become ossified forming loose bodies in the joint. There is sometimes reactive proliferation of the cartilage at the margins of the erosion and between the fissures. The bone itself may be involved and areas of rarefaction and condensation appear in the deeper layers (Fig. 138). Corresponding areas of degeneration often occur in the articular cartilage of the opposing surface of the femur. Chronic synovitis is not infrequently present in the later stages, and osteoarthritis follows when there is extensive destruction of the cartilage.

**Clinical Features.** There are often no symptoms until osteoarthritis develops in later life, but sometimes the onset is precipitated at an early age by a minor injury such as a blow or a twist. The first trouble is usually pain, often accompanied by an effusion into the joint, and

## CHRONIC KNEE SPRAIN

Chronic symptoms may be caused by an unresolved sprain of any of the ligaments of the knee, usually the internal lateral ligament, the coronary ligament or the cruciate ligament. The symptoms are due to the formation of a painful scar which restricts the full range of movements (*adhesion formation*). It is not uncommon for the trouble to persist for years either continuously or intermittently, the patient complaining variously of pain and weakness of the knee, that it lets him down, that he is afraid to use it, etc. Often the knee is symptom-free until some additional exertion makes it start hurting again, and perhaps swell, and then it takes some days to recover.

On examination during a period when there are no symptoms it may be difficult to detect any abnormal physical signs, but there is usually some wasting of the quadriceps, and there may be a localised point of tenderness, slight limitation of movement, particularly of extension and rotation, and passive abduction is often painful. If there is doubt about the physical signs when the patient is first seen, it is advisable to ask him to return for re-examination during an exacerbation when the signs are usually more definite.

Wasting and loss of tone of the quadriceps are almost invariably present when there is a chronic lesion of any severity. This is probably a "reflex" phenomenon and is not due in great part to disuse of the limb. The restoration of muscle power is an essential feature of treatment because stability is impaired as long as the muscles remain weak, but it is impossible to develop them fully whilst an organic lesion is present. Since wasting is a secondary and not a primary condition, there is seldom justification for the diagnosis of "quadriceps insufficiency" which is so often made when there is chronic knee trouble. There is no evidence that insufficiency occurs as an isolated entity without another lesion being present.

The first step in diagnosis is to obtain an accurate history going back to the primary injury and by careful cross-examination it is usually possible to reconstruct the precise details of the accident. This, together with the clinical findings and a negative radiological examination, is often sufficient evidence on which to base a diagnosis. Chronic sprain of the lateral ligaments can usually be recognized because the areas of tenderness are well away from the joint line, and pain is caused by passive abduction or adduction of the knee. Anterior cruciate ligament sprain is diagnosed when pain is felt "inside the joint" on full extension or on antero-posterior movement, and when there is no tenderness on palpation. With chondromalacia of the patella the history is usually intermittent and there may be pseudo-locking, but there is no restriction of movement and the tenderness, if any, is around the patella.

The chief difficulty in differential diagnosis is to distinguish between certain tears of the internal semilunar cartilage and sprain of the coronary ligament; in both the history is similar, pain and tenderness are in the joint line and there may be pain on rotation, flexion and extension. The

the whole patella or its lower half. Excision of the patella gives a satisfactory functional result provided the after-treatment is good, but it is a somewhat drastic procedure and should be reserved for the more serious cases. Trimming the cartilage is a useful procedure when early chondromalacic changes are found during the course of an operation that has been commenced on a mistaken diagnosis of a torn meniscus.

### Osteochondritis Patellæ

This rather uncommon complaint is in no way connected with chondromalacia of the patella although the symptoms may be somewhat similar. It is probably a form of osteochondritis juvenilis (p. 140) and closely resembles osteochondritis of the tubercle of the tibia and apophysitis of the calcaneus. There are two varieties: in the rarer type, the primary



Fig 139 Osteochondritis patellæ

centre of ossification of the patella is involved and the whole bone undergoes the typical changes. The more usual variety, which was described simultaneously by *Sinding-Larsen* and *Johansson*, affects only the lower pole of the patella where there is sometimes a small secondary centre of ossification.

The symptoms are seldom severe. The patient, usually a boy in the early teens, complains of pain and aching in the knee which is worse after use. There may be tenderness over the lower pole of the patella, and sometimes there is a small effusion into the joint. The X-rays show fragmentation of the anterior part of the lower pole (Fig. 139)

The condition has a short course and the symptoms usually disappear without treatment within a few months. It may be desirable to avoid games for a season, but immobilization is seldom necessary.

An extensive rupture extending into the lateral expansions of the tendon is a more serious injury. Active extension of the knee is impossible and a gap is palpable above the patella. Immediate operative repair of the defect is required, and the after-treatment is as for rupture of the patella ligament.

## Rectus Femoris

This muscle not infrequently gives way at the lower musculo-tendinous junction during active exercise. The muscle belly retracts upwards during contraction and makes a bulge in the centre of the thigh (Fig. 140).



Fig 140. Rupture of rectus femoris at the lower musculo-tendinous junction

Neither conservative treatment nor operative repair restore the original power to the limb which is unlikely to become good enough for first class athletics. Both methods, however, give a functional result that is satisfactory for all ordinary purposes, including games. The appearance of the limb is improved by operation.

The belly of the rectus femoris occasionally ruptures in the middle of the thigh in middle-aged and elderly people. This usually occurs in those who have suffered general deterioration in physique and gained a lot of weight. Operative repair is unsatisfactory because the muscle is fatty and friable and will not hold a suture. Conservative treatment commencing with rest and followed by physiotherapy brings about reasonable restoration of function.

## "Pulled Muscles"

This is a common athletic injury usually occurring early in season and when the ground is heavy. It consists in the rupture of a few muscle fibres, usually of the quadriceps fairly high in the thigh, and sometimes of the hamstrings or the calf muscles. It is a minor accident of no serious

temptation to attribute all such complaints to "cartilage trouble" must be resisted if only because removal of the cartilage on a mistaken diagnosis retards rather than accelerates recovery.

Manipulation is used as a diagnostic and therapeutic measure. It is likely to relieve a chronic sprain permanently, but a cartilage injury is not improved, except perhaps temporarily. If there is any doubt as to the diagnosis, the knee should be manipulated before deciding on operative measures. Manipulation is performed under general anæsthesia. The joint is moved through its full range, and this includes rotation, abduction and antero-posterior movement. Massage, active and passive movements and exercises are given afterwards, particular care being taken to retain the full range of accessory movements. Treatment must be continued until the wasted muscles have regained their strength; failure of the muscles to recover is an indication that the underlying disorder has not been relieved.

## RUPTURED MUSCLES

### Ligamentum Patellæ

Rupture of the patellar ligament is an unusual injury which occurs (*a*) in middle-aged people taking unaccustomed exercise, and (*b*) as the result of forcible manipulation of a stiff knee under anæsthesia. Diagnosis is simple; the knee cannot be extended actively, the patella is situated higher than in the other leg, and a gap is palpable where it should be possible to feel the ligament.

Conservative treatment is unsatisfactory and the defect should be repaired at operation. Within a short time of injury the fragments can readily be approximated and sutured, and an excellent result is obtained. After some time, however, the gap cannot be closed and end to end suture is impossible; it is then necessary to bridge the gap with a fascial graft, or to lengthen the quadriceps above the patella, but neither procedure gives as good a result as early operation.

After operation the leg is fixed in a plaster tube (Fig. 130). Weight-bearing is commenced a fortnight later, and after a month the plaster is removed daily for movements of the knee; protection whilst walking is necessary for a further period of a month.

### Quadriceps

The tendon of the quadriceps muscle may be torn at the level of the upper border of the patella, and occasionally a fragment of the bone is broken off. The injury is essentially the same as a transverse fracture of the patella, and is caused by the same mechanism, that is inco-ordinated muscular contraction.

When the rupture is limited in extent and involves only the central portion of the tendon, the power of active extension of the knee is very weak, but not completely lost. Conservative treatment by fixation in a plaster tube for some weeks is likely to be successful.



FIG 141 Sesamoid bone in the gastrocnemius muscle

nemius muscle must not be mistaken for a loose body (Fig. 141). Chronic arthritis occurs chiefly in middle-aged and elderly people and there are other signs of the condition. Recurrent dislocation of the patella, if seen when actually dislocated, is diagnosed at sight by the changed contour of the knee ; confusion only arises when the label of torn meniscus has already been attached by some misguided person.

## OSTEOCHONDRITIS DISSECANS

(*Synonym*) Paget's quiet necrosis

This is a fairly common condition in which an area of articular cartilage together with the underlying cortical layer of bone separates from the articular surface of the joint. It occurs most frequently in the knee and elbow although isolated examples have been described in several other joints. The knee accounts for at least 80 per cent of all cases and the elbow for about 10 per cent. The part of the knee typically affected is the inner condyle of the femur close to the intercondyloid fossa ; less common sites are the articular surface of the patella and the outer condyle of the femur. The condition is sometimes bilateral.

**Pathology.** No entirely satisfactory explanation of the phenomenon has yet been offered but there are two principal theories :—

(*a*) TRAUMA. Impaction of the patella or the tibial spine against the femur causing a fissure fracture of the affected part of the bone.

(*b*) EMBOLISM. The arteries supplying the juxta-articular region of

importance to ordinary people, but it may handicap a first-class man sufficiently to prevent him ever regaining his best form.

The most likely method of restoring perfect function is to insist on immediate active use without a preliminary period of rest. The limb is bound with elastoplast over a wide area; this limits effusion, and also provides resistance against which the contracting muscles can "squash out" the hæmatoma. The ordinary training programme should not be interrupted but competitive sport is avoided until the following season.

## √LOCKING OF THE JOINT

"Locking of the joint" is said to be present when movement is restricted by a temporary mechanical obstruction inside the joint. It is usually extension that is affected; there is free painless movement over the greater part of the range, but when the knee is straightened, movement is arrested at a point varying from 10° to 45° short of full extension. "Unlocking" may occur spontaneously, or as the result of manipulation; the patient feels a click as the obstruction is removed and full movement is immediately restored. True locking has to be distinguished from limitation of movement by muscle spasm. The latter occurs when there is a painful condition such as a sprained ligament and full movement is prevented by reflex muscular contraction (*pseudo locking*). True locking should only be diagnosed when there is also unlocking with immediate restoration of movement.

Locking occurs when a loose body or other structure which is free to move inside the joint becomes caught between the condyles of the femur and the tibia. The following classification of the causes of locking applies to all joints, except where structures peculiar to the knee are concerned.

1. *Local Conditions of the Joint.*
   - Torn or displaced semilunar cartilage.
   - Chondromalacia patellæ.
   - Osteochondritis dissecans
   - Osteochondromata, single, multiple or diffuse
   - Fracture of epiphysis with displacement of fragment.
2. *Chronic Arthritis.*
   - Nipped synovial fringe.
   - Detached osteophyte.
3. *Recurrent Dislocation of the Patella.*

The classical loose bodies are those in Group 1 which occur chiefly in adolescents and young adults. A tag of torn semilunar cartilage (Fig. 132) may behave as a loose body, and in fact this is the commonest cause of locking. Locking may occur on any occasion the joint is moved, even during sleep. There is a sudden, very sharp pain of momentary duration which recurs with each attempt at extension until the obstruction is cleared. A synovial effusion usually, but not invariably, follows.

The differential diagnosis causes little practical difficulty. Osteochondritis dissecans, osteochondromata and detached fragments of bone are shown on X-ray examination—the sesamoid bone in the gastroc-

intimation of trouble is delayed for years until the loose body has become detached and causes locking.

The early symptoms are weakness of the knee and rather vague pain. There is tenderness on pressure over the middle of the joint, extension may be slightly limited by muscle spasm, and there may be a recurrent effusion. Once the fragment has separated, the symptoms are those of a loose body (p. 184).

Diagnosis is made by the characteristic radiological picture. In the early stage the line of demarcation is clearly shown as a saucer shaped line in one of the typical positions (Fig. 143). After separation of the fragment, the loose body appears free in the joint and there is a corresponding depression in the place from which it has come.



Fig 143 Osteochondritis dissecans of the left knee

**Treatment.** A fragment, once separated, should be removed by operation at the earliest convenient moment. Operation is also a good method of treatment before the fragment has separated. The joint is explored and the articular cartilage examined ; if the fragment has nearly separated, it should be removed and the edges of the articular cartilage bevelled off. If, however, the articular cartilage appears fairly healthy and there is no actual break of continuity at the circular furrow, the further development of the process can often be prevented. The problem is to re-vascularize the bony portion of the fragment which has been cut off from its normal blood supply at the line of demarcation. This can be effected by drilling several holes through the fragment from the articular surface into the substance of the femur ; two or three holes with a 1/32nd inch drill suffice for a fragment of the usual size.

A few surgeons advise conservative measures and fix the limb in a walking plaster in the hope that re-vascularization will occur spontaneously.

the bone are functionally end arteries, and if one is obstructed, say by an embolus, the blood supply may be cut off and cause necrosis.

The process commences, usually during adolescence, in the cortical bone immediately underlying the articular cartilage (Fig. 142). A saucer-shaped area of bone is cut off by a thin layer of granulation tissue; the area is seldom bigger than a halfpenny, but occasionally it is very large and includes the major portion of one condyle. The articular cartilage at first shows no change, but after a time a circular furrow appears in it, and the furrow gradually deepens until it becomes continuous with the line of granulation tissue in the bone; meanwhile the articular cartilage changes colour until it becomes buff. A fragment consisting of articular

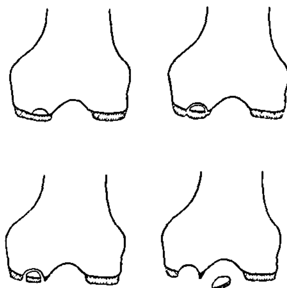


FIG 142 Diagram showing the development of osteochondritis dissecans (right knee)

cartilage and a thin layer of bone is thus formed; it remains *in situ* attached to the femur only by granulation tissue until it happens to be set free by a minor injury.

Histological examination of the fragment at the stage when there is still continuity of articular cartilage shows fairly normal cartilage adherent to a layer of bone which is in the process of absorption by the invading granulation tissue; degenerative changes in the cartilage commence at a later stage. After the fragment has separated, the granulation tissue on both surfaces of separation is replaced first by fibrous tissue, and finally by fibro-cartilage in which irregular ossification takes place. The loose body, when free in the joint, receives its nutrition from the synovial fluid; it continues to grow, often developing a lamellar structure, and ultimately it may reach a diameter of 2 cms. or more. The affected area of the femur becomes smoothed off and covered with fibro-cartilage, but osteoarthritic changes are common in later life.

**Symptoms.** Healthy active males are affected more frequently than females. There may be symptoms during the early stages before the fragment has separated, but frequently they are overlooked and the first

**Treatment.** The loose bodies should be removed and this is a matter of no great difficulty when only a few are present. In diffuse osteochondromatosis it is impossible to be certain that all have been removed; the osteochondromata are in all stages of development, many being as small as a pin's head, and even prolonged irrigation of the joint does not guarantee a complete clearance. Recurrence is very common, and although a synovectomy may be performed, fresh chondromata continue to develop. Arthrodesis may be necessary as a last resort after two or three arthrotomies have been followed by recurrence.



FIG 145 The loose bodies shown in Fig 143 after removal

## RECURRENT DISLOCATION OF THE PATELLA

Non-traumatic habitual dislocation of the patella occurs in young adults, usually females, and often bilaterally. The dislocation is almost always outwards, the patella slipping over the outer condyle of the femur during flexion of the knee. It happens "spontaneously" whilst running or walking; the knee suddenly gives way, there is acute pain and active extension of the limb is impossible. Passive extension of the joint causes the patella to slip back into place.

The history of "something slipping in the knee" which makes it lock renders the condition liable to be mistaken for a torn semilunar cartilage. The knee is usually straightened at once by the patient or his friends and it may not be seen by a doctor whilst the dislocation is actually present. Sometimes the patient can give a good description of the knee cap lying on the outer side of the joint, but often he is only aware of "something going out."

On examination, the patella can be made to ride over the outer condyle of the femur by pressing it outwards whilst passively flexing the knee. This manœuvre is necessary for diagnosis but it must be carried out carefully or the patella may be dislocated accidentally. It is sometimes possible to dislocate the patella of a "normal" joint in this way. X-rays do not as a rule show any abnormality, but occasionally it is possible to demonstrate flattening of the outer condyle.

## SYNOVIAL OSTEOCHONDROMATA

This condition, which is characterized by the development of cartilaginous or osteocartilaginous bodies within the joint, may occur in any of the large joints. The number of loose bodies may be limited to one or a few, but sometimes as many as two or three hundred have been found in a single joint. Symmetrical, bilateral affections have been recorded on a few occasions.

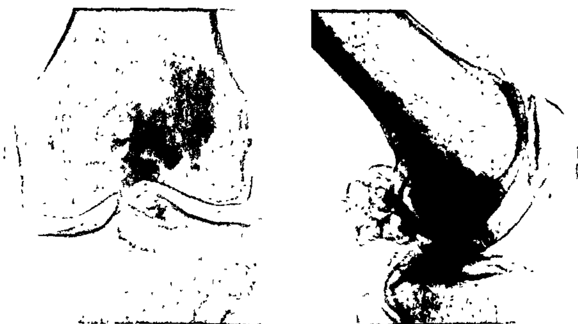


FIG 144 X-ray of the knee of a gardener aged 38 from which multiple loose bodies had already been removed on two occasions

Osteochondromata usually develop within enlarged synovial villi; at an early stage they are pedunculated, but sooner or later the pedicle separates and they lie free in the joint. There are two theories as to their causation. Firstly, it is suggested that frequently repeated minor injuries cause prolonged mild irritation of the synovial membrane which responds by hypertrophy. Secondly, it has been suggested (Kleinberg) that as a result of an abnormality in development there are aberrant mesenchymal rests in the synovial membrane; growth of these is stimulated, perhaps by trauma, and finally they undergo cartilaginous degeneration.

When only one or two loose bodies are present the initial symptom is usually locking, but when there is diffuse osteochondromatosis the onset of symptoms is often gradual. The patient then notices an increasing difficulty in using the joint and the range of movements gradually decreases, but it is astonishing how little disability may be present even when there are scores of loose bodies. Pain is not always a prominent feature but it may occur in association with effusion into the joint, especially after an unusual amount of exercise. Locking is a common but not invariable complaint, and sometimes the loose bodies can be palpated. The diagnosis is based on the radiological findings (Fig. 144).

3. Based on *Gallie's Operation.* A strip of fascia lata or joint capsule is used to anchor the patella to the inner condyle of the tibia. This also can be combined with type 2.
4. *Albee's Operation.* The external condyle of the femur is levered up to restore the normal joint level and the gap left in the bone is filled with a bone graft.

The choice of operation depends on the careful consideration of the individual patient ; a serious degree of knock-knee should first be corrected by osteotomy of the femur, Albee's operation is indicated if flattening of the femur can be demonstrated, and an operation of the Goldthwait group is necessary if the tibial tubercle is abnormally positioned. In the majority of patients, however, no abnormality of the femur or tibia can be demonstrated, and then operations of the Goldthwait and the Gallie type are equally successful, provided any abnormal bands of fascia are divided at the same time. The after-treatment of all the operations involves about six weeks fixation in plaster-of-Paris followed by physiotherapy ; weight-bearing in the plaster is usually possible after two weeks, except in the case of Albee's operation. ✓

## CHRONIC PAIN AND SWELLING

Chronic synovitis is not a diagnosis but a term descriptive of a particular pathological process, i.e. chronic inflammation of the synovial membrane, and this can be caused in several ways. It is an undesirable term because it may give rise to the mistaken impression that a diagnosis has been made, and it really is important to reach an accurate diagnosis before deciding on the line of treatment.

The commoner causes of chronic pain and swelling are :—

*Trauma.*
- Unresolved sprain.
- Torn meniscus.
- Chondromalacia patellæ.

*Loose Bodies.*

*Chronic Arthritis.*
- Rheumatoid arthritis.
- Osteoarthritis.

*Tuberculosis.*

*Syphilis.*
- Congenital.
- Acquired.

*Hæmophylia.*

*Intermittent Hydrarthrosis.*

The differential diagnosis between trauma and the other causes of chronic pain and swelling is seldom difficult because with the former the symptoms are intermittent, or are subject to frequent exacerbation, there is rapid improvement with physiotherapy and often permanent relief after

**Ætiology.** The following have been suggested by different authors as possible causes :—

1. Knock-knee. This deformity alters the line of pull of the extensor apparatus and may predispose to recurrent dislocation. Usually, however, there is no knock-knee and it is doubtful if knock-knee alone, except an extreme degree, can be held responsible.
2. Failure of development of the outer condyle of the femur which remains abnormally flat.
3. A patella situated abnormally high so that it lacks the support of the outer condyle.
4. Abnormal laxity of the capsule on the inner side of the joint.
5. An abnormal band of fascia leading from the outer border of the patella to the deep surface of the iliotibial band. The iliotibial band normally moves backwards during flexion and if a band is present, it may draw the patella backwards with it.

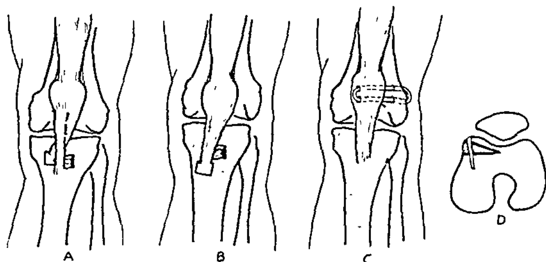



FIG 146 Operations for recurrent dislocation of the patella
A—Goldthwaite B—Hauser C —Gallie D—Albee

**Treatment.** Many operations of different types have been devised. Each depends on a different view of the ætiology, and all are successful with the majority of patients, but all fail occasionally. Failure may be due to lack of study of the factors involved in the particular patient concerned both before and during operation, and to rigid adherence to one technique in all circumstances.

The operations can be divided into four types each of which has several modifications (Fig. 146).

1. Based on *Goldthwait's Operation.* Transplantation of all or part of the patella tendon, together with the bone into which it is inserted, to the inner side of the head of the tibia, thus altering the line of pull of the extensor apparatus. It can be combined with an operation of type 2.
2. *Plastic Operations.* The inner side of the capsule is shortened and the outer side lengthened ; sometimes a flap of capsule is swung from the inner to the outer side. Abnormal bands of fascia are removed.

3. Based on *Gallie's Operation.* A strip of fascia lata or joint capsule is used to anchor the patella to the inner condyle of the tibia. This also can be combined with type 2.
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- *Loose Bodies.*
- *Chronic Arthritis.*
  - Rheumatoid arthritis.
  - Osteoarthritis.
- *Tuberculosis.*
- *Syphilis.*
  - Congenital.
  - Acquired.
- *Hæmophylia.*
- *Intermittent Hydrarthrosis.*

The differential diagnosis between trauma and the other causes of chronic pain and swelling is seldom difficult because with the former the symptoms are intermittent, or are subject to frequent exacerbation, there is rapid improvement with physiotherapy and often permanent relief after

manipulation. The presence of a loose body is recognized by the characteristic history and the X-ray appearances.

Osteoarthritis and rheumatoid arthritis are the common causes of chronic pain and swelling during middle age and after; syphilitic arthritis and hæmophilia are diseases of children, and tuberculosis is principally a disease of childhood although it does occur at all ages. Chronic swelling in young people is occasionally very puzzling and synovial thickening and effusion may persist for months or years defying every attempt at diagnosis. If there is reason even to suspect tuberculosis, active treatment must be withheld until the matter is settled one way or the other—a tuberculous joint treated with short-wave diathermy flares up in a shocking way!

## CHRONIC ARTHRITIS

### Rheumatoid Arthritis

**Generalized Disease.** The knees may be involved as part of a generalized affection (Plate V, p. 388). Careful splinting is necessary to prevent flexion contractures during both acute and chronic stages; splints should be worn at night for a very long time.



FIG 147 Rheumatoid arthritis with fixed flexion deformity Note the loss of joint space and the general rarefaction of the upper few inches of the tibia

Because of the frequency with which fibrous ankylosis occurs, it is important that all the joints of the leg and foot are in such a position that, when standing, the centre of gravity is in a stable position, i.e. above the feet. The optimum position for the knees is between 5° and 10° of flexion. Two stiff, nearly straight knees are a great disability because of the difficulty in getting up from a chair, but at any rate it is possible to walk after a fashion; with two bent knees, especially if other joints are stiff, walking may be impossible.

Flexion contractures are difficult to correct, but improvement can usually be obtained by continuous traction whilst the leg is suspended in a Thomas's splint with a knee flexion iron attached (Fig. 148). Another method is to use a turnbuckle attached to well-padded plaster cuffs on thigh and leg (Fig. 149). If conservative treatment fails, posterior capsulectomy may be necessary. This operation consists in excising the whole of the posterior part of the joint capsule, detaching both

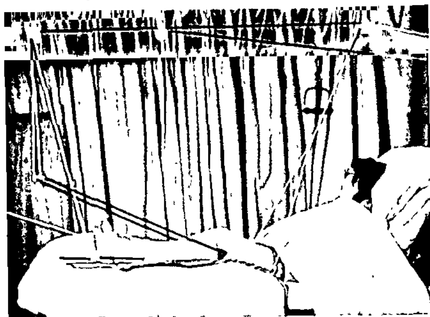


FIG 148 Flexion deformity of knee Correction by continuous traction



FIG 149 Flexion deformity of knee Traction is applied to stretch the joint capsule, and a turn-buckle to straighten the knee

heads of origin of the gastrocnemius from the femur and, if necessary, lengthening the hamstrings by oblique tenotomy; the knee should then be straightened slowly over a period of days to prevent damage to the main vessels and nerves. The operation often gives a satisfactory result with a stable knee and a useful range of movement. Arthrodesis may sometimes be desirable (see below).

**Chronic Bilateral Arthritis.** Disease of the knees of rheumatoid type, not affecting other joints, and without general manifestations, is very common. It occurs chiefly during middle age and after, and osteoarthritic changes are so often superimposed that it is difficult to be certain from which condition the patient is suffering.

The knees are painful on movement, especially immediately after resting, and after bearing weight for some time, they may be slightly

swollen, there is tenderness in the joint line and grating on movement. The response to simple physical treatment is fairly good but the symptoms tend to recur as the result of strain, and during cold or damp weather; deterioration, however, is very slow and it is usually possible to keep the patient reasonably comfortable by an occasional course of treatment.

**Subacute Monarticular Arthritis.** An affection involving one knee joint only occurs from time to time. The ætiology is quite unknown and there are not necessarily any manifestations of generalized rheumatoid arthritis. The condition resembles Sudek's post-traumatic atrophy and is [illegible] The articular cartilage is not affected and [illegible] chy rarefaction of the femur which gives [illegible] (Fig. 150). The rarefaction often starts *in one condyle of the femur and spreads slowly across the bone;* the patella is usually involved.



Fig 150 Subacute monarticular arthritis

Clinically there is gradual development of pain, swelling and limitation of movement. Pain is pronounced and is made worse by exercise; swelling is due mainly to effusion but there may be some periarticular thickening. The disease appears to run a course lasting between one and two years, and although it ultimately subsides, there is often some permanent disability.

Active treatment during the earlier stages increases the pain, and the joint should be placed at rest either in a walking plaster or a weight-relieving caliper. At a later stage physiotherapy, and sometimes manipulation under anæsthesia, are of benefit.

## Osteoarthritis

Osteoarthritis of the knee is common because it is a weight-bearing joint and because it is so exposed to trauma of all sorts. It may be caused by repeated minor injuries such as constant kneeling on a hard floor, or by a major injury like fracture of the tibial condyles. Loose bodies, whether composed [illegible] are a con [illegible] they are [illegible]

Chor [illegible] than is generally appreciated; the patello-femoral portion of the joint is affected first, then osteophytes form around the patella and damage the articular surface of the femoral condyles, and these in turn affect the tibia. The early stages of this process can often be seen at operation, and later stages are illustrated in Fig. 151 and Plate VI, p. 398.



FIG 151. Osteoarthritis of the knee

*Left*—In a patient with recurring displacement of the internal meniscus There is narrowing of the inner half of the joint space, irregularity in outline and some lipping of the inner condyle of the femur, and the tibial spines appear sharpened

*Right*—The patello-femoral portion of the joint is principally affected, probably as the result of previous chondromalacia patellæ.

**Signs and Symptoms.** There is gradual and increasing pain and limitation of movement. The pain is often worse on first straightening the knee after sitting, but it wears off with exercise; if the synovial membrane is inflamed, however, pain may be increased by exercise. Locking is not very common but it does occur as the result of nipping of an hypertrophied synovial fringe; unlocking may take place spontaneously but it is often necessary to free the joint by manipulation. Locking may also be due to a detached osteophyte which is lying free in the joint, and then unlocking is usually spontaneous.

On examination there is usually some wasting of the thigh muscles and both flexion and extension may be limited. Effusion and periarticular thickening are not marked unless there is synovial hypertrophy, but considerable effusion may follow a minor strain or nipping of the synovial fringe. There is usually tenderness in the line of the joint, over the retro-patella fat pads, and over osteophytic outgrowths, specially at the margins of the condyles of the femur and the borders of the patella. Coarse grating is palpable on movement when the articular cartilage is eroded, but finer crepitations are felt at an earlier stage.

**Treatment.** PHYSIOTHERAPY. Most patients can be kept tolerably comfortable for a considerable time by physiotherapy. Short-wave diathermy is usually the best method of administering heat; massage assists in reducing periarticular thickening and adds considerably to comfort; exercise is important to keep a good range of movements and prevent the muscles from wasting.

MANIPULATION under an anæsthetic is sometimes necessary to free a nipped tag of hypertrophied synovial membrane. The injured tag is bruised and œdematous and it may adhere to another part of the joint forming an adhesion unless care is taken to maintain movements after manipulation. Manipulation is also of value in increasing the range of movements when it is restricted by contraction of periarticular tissues.

A WEIGHT-RELIEVING CALIPER usually gives considerable relief from pain but it is only occasionally tolerated by the patient. It should be fitted with a knee hinge that can be locked at 180° for walking and released for sitting.

JOINT ACIDIFICATION. See p. 403.

OPERATION is of value in certain patients and the following are the *indications*:—

(*a*) *A Loose Body* or torn semilunar cartilage should be removed during the earlier stages in order to reduce the rate of deterioration of the joint and prevent the occurrence of acute symptoms due to locking. It should, however, be explained to the patient that the arthritis is not cured by the operation, and that it may get worse later in life.

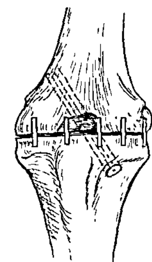


FIG 152

(*b*) *The Patella* may be excised when the pathological changes are restricted to the patella and the corresponding part of the articular cartilage on the anterior surface of the femur. An excellent result with a good range of movement and almost normal function may be obtained in properly selected cases, but if there are also symptoms arising from the tibio-femoral articulation, the result will be disappointing.

(*c*) *Arthrodesis* is indicated chiefly in unilateral disease when there is severe pain. One stiff knee gives surprisingly little disability and is a small price to pay for a painless leg (unless it happens that

flexion of both knees is essential for some particular occupation). There is only a slight limp when walking, and the chief disadvantage is the way the leg sticks out when sitting.

Arthrodesis of the knee was formerly rather a lengthy procedure involving many months in a plaster cast before bony union was obtained. This difficulty is now overcome by using cancellous bone grafts. The author performs a simple excision of the joint by making parallel cuts with a saw through the lower end of the femur and the upper end of the tibia. The bones are fixed together with a tri-fin nail and then some half-dozen inlay grafts of cancellous bone cut from the ilium, or from the part of the femur that has been removed, are placed across the junction (Fig. 152). The patient remains in bed with the leg in plaster-of-Paris for a month, and then weight-bearing is commenced with the leg protected by a plaster sleeve extending from groin to ankle. Union is usually secure after a further three or four weeks.

## TUBERCULOSIS

Tuberculosis of the knee is essentially a disease of early life. It is not uncommon during the first year, and the incidence rises to a maximum at about the fourth or fifth year and then fails gradually. In adults the knee is affected relatively more frequently than are other joints, and adolescents and young adults provide a fair proportion of cases.

The infection, as in other joints, is always secondary to a tuberculous lesion elsewhere in the body. The initial focus in the knee is usually in the juxta-articular bone of the lower end of the femur or the upper end of the tibia, and very occasionally in the patella. Sometimes it is in the metaphysis close to the epiphysial line and then the disease is extra-articular for a time, but it soon spreads to the epiphysis and the joint (Fig. 153).

The infection may remain predominantly synovial throughout the whole course of the disease but it is probable that the articular cartilage and subchondral bone are always involved as well, even if only to a limited extent (Chap. XI). There is some dispute as to whether or no the initial infection in such cases is in bone or synovial membrane, but the problem is chiefly of academic interest.

### Signs and Symptoms

Pain. The onset usually is gradual and pain may not be prominent although it is always present in some degree. It is felt chiefly on moving the joint, or on jarring or twisting it. Occasionally the onset is more rapid and accompanied by severe pain.

Limp is usually present at an early stage, but not invariably. The limp is due to the knee being held in a partly flexed position and it becomes more marked as the deformity increases.

Swelling is often the first complaint. The synovial membrane is thickened and the joint cavity and supra-patellar pouch become distended with tuberculous material. The swelling often starts on each side of the patellar ligament and increases gradually until the knee has acquired a

characteristic bulbous appearance (Fig. 154). On palpation there is a typical "doughy" feeling due to the consistence of the material in the joint; this feature is of importance in distinguishing tuberculous infection from other forms of arthritis. The affected knee usually feels a little warmer than the other, and the superficial veins may be distended but the skin is often white in colour.

WASTING of the muscles, which is rapid and affects both calf and thigh, accentuates the appearance of swelling of the joint.

MUSCLE SPASM causing limitation of movement occurs very early. Both flexion and extension are restricted and the typical contraction of the muscles can be seen on making a sharp movement.

DEFORMITY. The knee is at first held in slight flexion because in this position the ligaments are relaxed and the capacity of the joint is increased. At a later stage flexion is increased by the pull of the hamstrings because when the joint is partly flexed they have a great mechanical advantage over the extensors. In the final stage the tibia is displaced backwards on the femur and also rotated externally because of the greater power of the biceps. Some genu valgum is common. The classical deformity, which develops in the absence of treatment, is flexion to a right angle combined with posterior subluxation and external rotation (Fig. 154).

GROWTH. Enlargement of the epiphyses of the diseased knee as compared with the sound one not infrequently occurs in children. Growth in length may also be accelerated and the affected limb becomes longer than the other. The increase in length affects chiefly the tibia and therefore the head of the fibula appears to be lower than normal. The total lengthening may be as much as an inch during the active stage of the disease but the rate of growth diminishes later and there is not as a rule much permanent increase in length.

### Diagnosis

IN YOUNG CHILDREN there is seldom any real difficulty. The knee is swollen, movement is restricted by muscle spasm and there is X-ray evidence of diminished density of the bones forming the joint, destruction of bone and narrowing of the joint space (Fig. 155).

IN OLDER CHILDREN AND ADOLESCENTS there may be considerable difficulty in the differential diagnosis from chronic synovitis due to trauma. Occasionally tuberculous synovitis persists for months, and even years, without radiological evidence of bone involvement, and without the characteristic clinical appearance developing. The symptoms usually subside with rest, but tuberculosis should be suspected, although it may be difficult to prove, if they recur each time free use of the limb is permitted. Examination of fluid removed by aspiration seldom yields a positive result; biopsy of the joint is contra-indicated at this age because of the risk of sinus formation, but biopsy of an inguinal gland may be helpful. Swelling due to congenital syphilis can usually be recognized by the comparative painlessness and positive serological tests; it often commences in one knee but usually becomes bilateral within a few months.



Fig. 153 Tuberculous disease of the knee The infection started in the metaphysis



Fig 154 Tuberculous disease of the knee showing the deformity in a patient who had had no treatment (by courtesy of Prof H J Seddon).

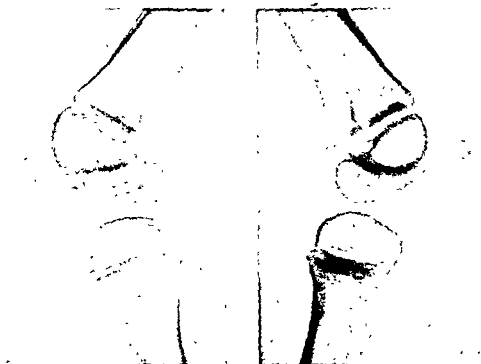


Fig 155 Tuberculous disease of the left knee There is irregularity in outline of the femoral condyles, general rarefaction of bone, and enlargement of the epiphyses of the femur and tibia and of the patella

In Adults, especially in the middle-aged and elderly, differentiation from sub-acute monarticular arthritis of rheumatoid type is sometimes impossible on clinical and radiological evidence alone without observation over an unduly long period. Biopsy of the joint is permissible if it is intended to perform a radical excision or an amputation should tuberculosis be proved.

## Treatment

**Children.** The response to conservative measures is reasonably good but a long period of treatment in appropriate conditions, preferably an open-air hospital, is essential (Chap. XI). Unfortunately the infection not infrequently fails to subside completely and flares up again after an interval that may be as long as twenty years; there is therefore a strong case for arthrodesis when the disease is quiescent.

Local treatment consists in immobilization of the joint preceded, when necessary, by correction of existing deformity. The following methods of immobilization are used :—

Thomas's Bed Knee Splint with fixed extension is suitable for early disease without very much deformity. Good control is obtained and free inspection of the joint permitted, but with infants the splint is hard to apply and nursing is difficult.

Thomas's Splint with Weight Extension and a knee flexion iron may be used to correct gross deformity. The direction of pull should be a few degrees less than the angle of deformity; posterior subluxation is corrected by a band passing behind the head of the tibia to lift it forwards. Weight extension is valuable in overcoming muscle spasm but it should not be continued too long because it does not give good immobilization, and because the joint surfaces should not be held apart indefinitely or healing will be delayed.

Plaster-of-Paris, since it gives fair immobilization and is easy to apply, is the method of choice at many hospitals. The plaster should be bivalved to permit regular inspection of the joint. The foot should always be included in the plaster, and in children the pelvis also.

Recumbent treatment is continued until there are no longer any local or constitutional signs of active disease and the X-rays show that re-calcification of bone is well advanced. A weight-relieving caliper may then be applied and a limited amount of activity permitted. The caliper is worn day and night but it should be removed daily by a nurse to give attention to the skin of the buttock and to wash the foot. Weight-bearing is commenced when the structure of the bone has returned to normal, but protection from strain should be provided for a very long time by means of a leather corset or similar appliance.

Arthrodesis. The end result when there is gross destruction of the articular cartilage is fibrous ankylosis, but when the infection has remained predominantly synovial, a limited range of movement may be retained. Neither fibrous ankylosis nor a limited amount of movement can be regarded as safe conditions offering reasonable security from re-activation

of the disease, and therefore operative arthrodesis always requires consideration.

Some surgeons postpone arthrodesis until about fifteen years of age because of the possible risk of interfering with growth, but this complication should not occur with a well-planned operation. It is carried out by the same method as in adults and it is desirable to remove all the synovial membrane (see below).

The lower femoral epiphysis occasionally becomes displaced by the strain of a stiff knee and causes some genu recurvatum, but should this happen it can be corrected by osteotomy.

**Adults.** The response to conservative treatment is not as a rule good: a useful range of movement is seldom, if ever, obtained and sound fibrous ankylosis is uncommon. Operative measures are therefore indicated at a comparatively early stage, but it is important to provide a preliminary period of general treatment in an open-air hospital in order to observe the virulence of the infection and the reaction of the patient. General treatment is also necessary to combat the other foci of disease that necessarily exist; the frequency with which the inguinal glands are involved shows that there must be fairly extensive disease of the lymphatic system.

In young adults, when the general condition is satisfactory and it has been shown radiographically that the local infection has been checked, the joint may be excised and arthrodesed. In later life, and sometimes in younger people when the disease progresses rapidly in spite of immobilization, amputation is preferable.

Excision and Arthrodesis. The object is to remove all infected tissues and secure bony union between the femur and the tibia. A wide exposure [illegible]

The upper end of the tibia [illegible] healthy bone and the patel[illegible] bones are cut at such an an[illegible] at the knee. The limb is [illegible] bearing is commenced as early as possible, preferably within four to six weeks of operation, in order to force the bones into apposition. No form of metallic internal fixation should be used, but it is probable that cancellous iliac grafts can be introduced to increase the speed of union without adding to the risk (p. 196).

Amputation. The response to conservative treatment during later life is notoriously bad. [illegible] the elderly, and many [illegible] age. It may be indica[illegible] any age when the response to immobilization is unsatisfactory, when there is severe secondary infection, or when there are other major tuberculous lesions and the general condition is poor. General treatment must be continued in spite of amputation until all other lesions are quiescent.

## SYPHILIS

Joint lesions may occur in congenital syphilis, and during the secondary and tertiary stages of acquired syphilis.

### Congenital Syphilis

**Infants.** Acute symptoms occurring in babies are described with other acute infections on p. 367.

**Adolescents.** Chronic symptoms are rare but there is a form of chronic arthritis due to gummatous infiltration of the synovial membrane that is very occasionally seen (Clutton's joints). It is characterized by bilateral, fusiform swelling of the knees, and very rarely of other large joints. The onset is rapid and the effusion considerable, but the condition is nearly painless. The response to anti-syphilitic treatment is good.

### Acquired Syphilis

**Secondary Stage.** There is sometimes an effusion into the larger joints, usually the knees. The distribution is often symmetrical and occasionally several joints are affected. Sometimes it is painful but often there is little if any pain. The size of the effusion may vary considerably during the course of the disease and it can be extreme.



Fig. 156 Charcot's disease of the knee

**Tertiary Stage.** The periarticular tissues of the larger joints, usually the knees, may be the site of a gummatous process. Occasionally the articular cartilage and underlying bone are also involved and then there is gross disorganization of the joint.

The commonest manifestation of syphilis in joints occurs in connection with tabes dorsalis (*Charcot's joints*) and is described on p. 405. The knee is affected more frequently than any other joint, usually by the hypertrophic type (Fig. 156). It should be suspected when there is a painless arthritis with gross effusion and rapidly progressive destruction of bone.

## HÆMOPHILIA

Hæmorrhage into a joint is a common manifestation of this distressing disease. The knee is involved most frequently but sometimes the hip, the elbow and occasionally the smaller joints are affected. Bleeding is often started by a minor injury or sprain.

A single hæmorrhage may be absorbed without damaging the joint, but repeated hæmorrhages cause serious disorganization. The joint capsule is stretched and weakened, the synovial membrane hypertrophies and proliferates, and its surface becomes covered with pedunculated, polypoid excrescences. The articular cartilage degenerates and flakes off, and ultimately osteoarthritic changes supervene. The interior of the joint is stained brown.

The diagnosis is obvious except during the first attack. There is a sudden hæmorrhage into the joint, often after a trivial injury that would not be expected to produce such a result. There may be a slight fever, the joint is swollen, tender and feels firmer than with a serous effusion.

The blood gradually absorbs with rest and the symptoms subside. The joint returns almost to normal after the first few attacks, but once deterioration has commenced, each subsequent attack leaves it worse and it becomes permanently painful and swollen, and the muscles waste. At this



Fig 157 Hæmophilic knee The outline of the femoral condyles is irregular and the epiphyses are enlarged.

stage there is some clinical resemblance to tuberculous disease, but later the symptoms are those of severe osteoarthritis.

**Treatment.** After a fresh hæmorrhage complete rest with the leg bandaged to a plaster back-slab is desirable until the blood has been absorbed. The joint should be aspirated if it is distended, but a fine needle should be used because a large one may cause further bleeding. Massage is unwise, but heat applied superficially appears to be without ill effect. If there are frequent attacks, the knee should be protected by a walking caliper. Operation is contra-indicated.

## INTERMITTENT HYDRARTHROSIS

This uncommon condition, which affects principally women, is characterized by an effusion into a joint or joints recurring as a rule with regular periodicity. The ætiology is obscure but the disease is commonly accepted as being similar to angioneurotic œdema.

The onset is usually during adolescence or early adult life, and once established it persists for many years. The knees are the commonest joints to be involved although any of the large joints may be affected. It is frequently bilateral but the onset in the second joint may be delayed until years after the first, and occasionally four or more joints are involved. The synovial membrane at first is normal but after a time it becomes thickened and inflamed, and eventually a pannus spreads over the articular cartilage. The synovial fluid shows no unusual features by which it can be identified.

Periodicity is a typical feature although occasionally it is absent. The period varies with the individual from four to thirty days, the average being about twelve days and it may take some time to become regular. The maximum swelling is reached in two or three days and then it gradually subsides. During the brief intervals between attacks the joint becomes nearly normal, but with old-standing disease some synovial thickening remains palpable. At first pain is not marked and seems to be due chiefly to mechanical interference by the effusion, but it is more prominent at a late stage when pannus is invading the articular surfaces. Long spontaneous remissions may occur, and there is almost invariably a remission during pregnancy and the early part of lactation.

**Treatment.** There is no specific treatment. A conservative attitude should be adopted at first and the fullest investigation made. The usual search is made for focal sepsis, the anaphylactic reactions are tested and the patient is immunized against any substances causing a reaction. Psychological examination is important because some early cases are claimed as entirely relieved after psychotherapy.

The majority of patients fail to respond to conservative measures and sooner or later the inconvenience of the recurring disability becomes so great that they demand further interference. Complete excision of the synovial membrane is then indicated. The operation gives a movable joint and on the whole is worth while, but unfortunately the new lining which forms in the joint sometimes produces fluid as rapidly as did its predecessor. In spite of this risk the operation is worth performing—patients so appreciate even a temporary relief from symptoms that they come back and demand that it is repeated.

Arthrodesis is seldom advisable owing to the frequency of bilateral involvement. Even when only one knee is giving serious trouble it is dangerous to stiffen it permanently because the other may later get worse, but just occasionally, when there is gross destruction of the articular cartilage, the pain may be so severe that arthrodesis is the only way to relieve it.

# SWELLINGS AROUND THE KNEE

The majority of swellings around the knee are caused by enlargement of structures peculiar to the knee, but it must be remembered that other tumours such a lipomata and fibromata also occur. Many of the swellings are cystic but they are readily seen to be distinct from swelling of the whole knee due to effusion into the joint.

The commoner causes of swellings are :—

*Anterior.*
- Prepatellar bursitis.
- Osteochondritis of the tibial tubercle.

*Posterior.*
- Semimembranosus bursitis.
- Popliteal hernia.
- Popliteal aneurism.

*External and Internal.*
- Cysts of the semilunar cartilages.

## PREPATELLAR BURSITIS

There are at least three bursæ in front of the knee. The largest is superficial to the lower pole of the patella and the upper part of the patellar ligament, a small one lies superficial to the tibial tubercle and the lower part of the patellar ligament, and a third is between the patellar ligament and the head of the tibia. Any of these bursæ may become enlarged or infected, but the commonest to be involved is the large one in front of the lower part of the patella, commonly known as the prepatellar bursa.

Simple enlargement of the prepatellar bursa (*housemaid's knee*) may be caused by repeated minor traumata, or by a single blow, but often it occurs without apparent cause. The large sac forms a prominent swelling over the lower part of the knee which cannot readily be mistaken for anything else (Fig. 160). Sometimes a hæmorrhage into the bursa causes a hard swelling resembling a solid tumour.

**Treatment.** Aspiration of the fluid is frequently followed by recurrence. Aspiration and injection of a sclerosing fluid may be successful in obliterating the bursa but it sometimes leaves a subcutaneous scar that remains tender for a long time and interferes with kneeling. Excision of the bursa is the usual method of treatment of chronic enlargement ; it is carried out through a lateral incision to avoid leaving a cutaneous scar at a place where it is subject to pressure.

**Inflammation.** Infection of the bursa is common and is accompanied by the usual signs of acute inflammation. The patella and the knee joint, which are separated from the bursa by the thick tendinous expansion of the quadriceps, are seldom infected secondarily, but sometimes there is a sterile effusion into the joint. The infection can often be controlled by penicillin administered either by injection into the bursa or systemically. If an incision is necessary for drainage, it must be placed laterally and never in the mid-line.

## OSTEOCHONDRITIS OF THE TIBIAL TUBERCLE

(*Synonym*) Osgood-Schlatter's Disease

An expansion of the upper epiphysis of the tibia extends downwards in front of the shaft to form the tibial tubercle. This *tongue of ossifying* cartilage is subject to a disorder that is possibly analogous to Perthes disease of the hip and Kohler's disease of the tarsal scaphoid. The pathology is discussed under Perthes disease on p. 140.

Males are affected more frequently than females, perhaps because of the greater liability to trauma. The onset is typically during the early teens and the symptoms are pain and swelling. Pain is usually, but not



Fig 158 Osteochondritis of the tibial tubercle of the right knee

invariably, present and is worse after exercise; there is always swelling and sometimes this is the only symptom. On examination there is tenderness over the tibial tubercle, swelling and frequently some heat; passive movements are painless, but active extension may cause pain. The bursa *situated deep to the patellar ligament* sometimes becomes *inflamed and* distended, and then pain on active use is more marked.

X-rays (Fig. 158) show irregularity in the ossification of the tibial tubercle. The outline is irregular and there are patchy areas of rarefaction and sclerosis. Because the normal tibial tubercle is subject to considerable variation both in outline and structure, the diagnosis should not be based on the radiological appearances alone but made in conjunction with the clinical findings.

**Treatment.** The disease runs a course lasting from a few months to two years, and complete anatomical and functional recovery takes place

in the absence of all treatment. There is no necessity for physiotherapy or for immobilization of the knee, but it is desirable to avoid games and strenuous exercise as long as pain persists.

Resolution can be accelerated by increasing the local blood supply of the tubercle by drilling holes through it into the shaft of the tibia. The operation may be justifiable, particularly in older patients, when there is a special need to become fit for games as quickly as possible.

Inflammation and enlargement of the bursa behind the patella ligament occasionally causes sufficient pain to call for excision.

## SEMIMEMBRANOSUS BURSA

There are six bursæ situated on the postero-internal aspect of the knee. The principal one, that which usually gives rise to trouble, lies between the inner head of the gastrocnemius and the tendons of the semimembranosus and semitendinosus muscles. It often communicates with neighbouring bursæ and usually also with the knee joint; the opening into the knee lies high up under cover of the inner head of gastrocnemius.

Simple enlargement of the bursa occurs at any age from childhood onward and it is more frequent in males than females. It might be expected that a bursa communicating with the knee could not become distended with fluid unless the joint were distended also. The usual explanation of the phenomenon is that the muscles exert a valve-like action on the communication which prevents the bursa emptying; variation in the size of the bursa is explained by the occasional release of the valve.

The enlarged bursa appears as swelling on the posterior aspect of the knee internal to the mid-line and either above or level with the popliteal crease. It is more prominent when the knee is extended. On palpation when the muscles are relaxed by flexing the knee, it is felt as a tense, round, movable swelling. The bursa cannot be emptied into the joint by pressure even when a communication exists. An effusion into the knee is only occasionally present. Pain may be caused by irritation of the bursa by muscular activity.

**Treatment.** If symptoms are troublesome, the bursa may be excised. The incision should be transverse because a straight vertical scar behind the flexure is likely to contract. The dissection is carried to the base of the bursa which is always adherent to the gastrocnemius and semimembranosus muscles.

## POPLITEAL HERNIA

(*Synonym*) Baker's Cyst

Morrant Baker described a number of cases of posterior herniation of the knee in 1877, and since then some confusion has been caused by the habit of attaching his name to all swellings at the back of the knee. Baker's specimens have been re-examined by Gask and Wilson who consider them to be tuberculous. There is therefore some justification for referring to tuberculous herniation as a Baker's cyst, but in the absence of more accurate definition, it is better not to use the term.



Fig 159 Air arthrogram showing posterior herniation of the knee joint

True posterior [illegible] posterior capsule which is just below the centre of the oblique ligament. The hernia passes backwards between the two heads of the gastrocnemius to become subcutaneous and then it tends to gravitate down the calf. The visible swelling is level with the popliteal crease or below it. Occasionally there are multiple herniæ.

Posterior herniation is accompanied by more severe symptoms than is a semimembranosus bursa. There is often pain, effusion and muscular wasting; the leg below the knee may swell because of pressure on the popliteal veins. Symptoms in the knee frequently precede the appearance of the hernia.

**Treatment.** Investigation of the ætiology must always be made because operation is contra-indicated in the presence of tuberculous infection. When of non-infective origin, the hernia may be excised and the opening through the capsule sutured. This relieves symptoms due to the hernia but not, of course, those due to concomitant arthritis.

## CYSTS OF THE SEMILUNAR CARTILAGES

These are the only important cause of swelling on the outer or inner sides of the knee and they account for almost all swellings except those due to superficial tumours such as lipomata and fibromata (Fig. 160). Cysts are more common in connection with the external than the internal cartilage, the relative frequency being about 8 to 1.

The cysts are said to originate in remnants of the undifferentiated mesoderm from which the semilunar cartilages are derived. They are multilocular, lined with endothelium and filled with gelatinous material. They usually develop in the cartilaginous substance of the peripheral, convex border of the meniscus, as a rule in the middle third; very rarely they are situated at the anterior or posterior horn close to the insertion into the tibia. They are not connected with the joint capsule which is stretched over them, much thinned and attenuated when the cyst is large. Occasionally the cyst passes between the fibres of the capsule and appears as a sesile or pedunculated subcutaneous swelling.

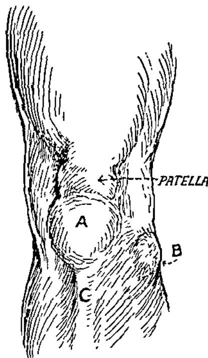



FIG 160 Swellings around the knee
A. Prepatellar bursitis
B. Cyst of the external cartilage
C Osteochondritis of tibial tubercle

Patients may present themselves for advice for the first time at any period from adolescence to late middle age. In the latter case it does not follow that the cyst is of recent growth because small cysts may remain symptomless for many years. The usual complaint is of pain in the knee made worse by exercise, and the swelling may or may not have been noticed by the patient. There is often a history of trauma which either precedes the onset of symptoms or causes an exacerbation. Examination shows a swelling in the joint line or just below it, usually in front of but sometimes behind the external lateral ligament; when small it is detected only on careful palpation and comparison with the other knee. The larger cysts are quite tense and are often mistaken for bony protuberances.

**Treatment.** It is not necessary to operate on every patient, particularly older people, because often the symptoms are not due entirely to the cyst. In active people, however, a cyst of any considerable size causes sufficient irritation to the surrounding structures to be a constant trouble and operation is desirable. Local removal of the cyst without the semilunar cartilage from which it springs is frequently followed by recurrence. Excision of the cyst and cartilage together may cause unnecessary damage to the external capsule of the joint. It is usually sufficient to remove the cartilage only; the cyst may then be evacuated into the joint by pressure and it does not recur.

##  CLICKING KNEES

Audible clicking is sometimes the chief symptom of which a patient complains. It may be accompanied by pain but often there is no other symptom than noise.

### "VACUUM CLICK"

This is the commonest type. It may occur in any joint and can be produced by many people at will, e.g. in a metacarpo-phalangeal joint by pulling the finger. A possible explanation is that slight separation of the joint surfaces increases the potential capacity of the joint and creates a vacuum ; the capsule which has momentarily been held away from the bone is then sucked in with a snap.

Clicking joints of this type may be of great annoyance ; in an extreme example a simple action like walking up stairs is accompanied by a regular fusilade. The clicking may occur during normally executed movements, or it may only happen when a particular twist is given to the joint and some people form the habit of always moving in this peculiar way. Treatment is only possible in the latter, the abnormal movement being analysed and explained to the patient who may then be able to break the habit.

### EXTERNAL SEMILUNAR CARTILAGE

A torn cartilage or a congenital disc cartilage may cause clicking (p. 172). With a disc cartilage the click, or thud, has a base pitch quite distinct from the treble "vacuum" click.

### CLICKING TENDONS

**Biceps Tendon.** The tendon of the biceps femoris is inserted into the lower part of the outer surface of the head of the fibula. It is separated from the upper part of the head by a bursa and normally it slips smoothly backwards and forwards. When clicking is present the tendon catches on the bone and flicks across causing pain with each movement of flexion and extension. The click can be both heard and felt. The treatment is to fix the tendon to the underlying bone ; this gives complete relief from symptoms and causes no disability.

**Popliteus Tendon.** The tendon of the popliteus muscle may slip in and out of its groove on the lateral condyle of the femur making an audible and palpable click. It is difficult to fix the tendon firmly in the groove without interfering with the function of the knee, but relief from symptoms is given by chiselling away the raised border of the groove to allow the tendon freedom of movement.

**Joint Capsule.** The joint capsule, or more properly the extensor expansion of the quadriceps muscle, may occasionally click over some small protuberance on the anterior part of one or other of the condyles of the femur. It is cured by removal of the protuberance.

With all clicking joints it is an advantage to operate with local anæsthesia because the mechanism of the click can then be demonstrated by the active movements of the patient.

## CHAPTER VI

# THE FOOT AND ANKLE

THE feet are the hardest worked and most mis-used parts of the body. They have to carry the whole body weight and withstand the shock of meeting the ground at each step, they are confined in shoes that are often ill-fitting, and they have to walk on surfaces that seem to get harder each decade. It is surprising, not that there is so much foot trouble, but that there is not more.

The foot is an intricately fashioned structure and its careful balance is easily disturbed. Every disorder in function, and every minor deformity or injury that causes pain, produces further disorder in function and yet more pain. It is not always easy to decide the primary cause of trouble because pain may either be felt locally at a deformed bone or joint, or it may be felt chiefly elsewhere, for example under the outer metatarsal heads on which undue weight is being taken to avoid a bunion.

The key to understanding lies in the study of function and of the mechanism by which pain is produced. There is no mystery about the pain and its causes are exactly as elsewhere in the locomotor system. Deep pain is usually due to tension on ligaments or fascia, to pressure on damaged or inflamed joints, or to ischæmia; superficial pain is caused by irritation of the skin. Deformities do not always cause pain; a large-scale study of infantrymen by Buxton showed that men with minor deformities were no more likely to report sick on account of their feet than those with apparently normal feet.

*Children* seldom suffer from painful feet except from visible causes such as chilblains, warts and corns; deep-seated pain like that due to chronic foot strain or metatarsalgia is uncommon. There are, however, a few conditions causing deep pain in children, for example osteochondritis of the navicular, the calcaneus or the metatarsals; tuberculosis is not common but it may affect any bone or joint in the foot. Most problems in children's feet are concerned with their shape or function, e.g. "flat foot," hallux valgus, clawed toes, etc., and the possible effect of such deformities in later life.

The posture and movements of the feet are described on p. 14.

## "FLAT FOOT"

Different complaints are too frequently labelled "flat foot," but the confusion can be eliminated by appreciation that "flat foot" is a physical sign and not a diagnosis. A foot that looks flat is almost invariably a valgus foot, and since pes valgus is a postural defect, it is discussed with other postural defects in Chap. I (p. 20).

It cannot be over-emphasized that pes valgus is not ordinarily a painful condition. Pain in a foot that happens to be valgus should not straight away be attributed to the posture but the real cause determined; this may be any of the conditions that cause painful feet, for example, hallux valgus, anterior metatarsalgia or plantar fasciitis.

When the pain is directly associated with the posture one of the following conditions is likely to be present :—

1. Chronic Foot Strain. This is a disorder occurring in adults, but very seldom in children, in which pain is caused by a *change* in posture from "normal" to valgus. It is further discussed below.

2. Peroneo-Extensor Spasm, or "Spasmodic Flat Foot." This is a complaint of adolescents although symptoms may persist into adult life. It is described on p. 214.

3. Congenital Flat Foot, an extremely rare condition caused by a congenital structural anomaly (p. 217).

## CHRONIC FOOT STRAIN

Restriction of movement at the inter-tarsal and tarso-metatarsal joints is a common cause of pain. The ability of the foot to resist the strain imposed on it depends on its resilience ; the muscles allow it to yield as it receives the body weight and then impart the spring that carries it to the next step. The ligaments of a supple foot are not under tension during ordinary movements and therefore a supple foot is seldom painful: but when movements are restricted, even slightly restricted, by reason of injury or disease of the ligaments, the ligaments are exposed to strain.

The muscles, not only the muscles of the foot but all the extensors of the legs and trunk, relax when they are fatigued from such causes as prolonged and unaccustomed standing, a rapid increase in body weight, a long illness, and sometimes a short acute illness. The foot then rotates into the valgus position under the influence of the body weight, and provided there is normal mobility, the inner border of the foot rests nearly on the ground without placing much strain on the ligaments (Fig. 14, p. 15); this may give rise to some tiredness and aching but not to any considerable pain. If, however, the foot is unable to rotate into valgus, the strain is taken by the ligaments and pain is caused.

*Mobility is the key to the problem of this type of painful foot. A supple foot, whatever its habitual posture, seldom causes serious trouble ; but a stiff foot, whether it is stiff because of an unresolved sprain, arthritis, or contraction of the ligaments, is liable to become painful when subjected to strain. The stiffer the foot, the smaller the range of movements and the greater the risk of pain.*

## Symptoms

Pain is the chief complaint. At first it is well localized, usually at the inner border of the foot, and it is perhaps felt only when tired and is relieved by rest. Later it becomes nearly constant, it is aggravated by weight-bearing, and it often radiates widely over the foot and calf. There may be some superficial œdema of the foot and ankle which gets worse towards the end of the day and disappears during the night.

On examination, there is usually, but not invariably, tenderness on pressure over the affected ligaments; there is limitation of passive movement in at least one direction, and pain at the extreme of that movement. X-rays are negative except when there is arthritis. The presence of minor deformities is of importance only in so far as they may be causing the foot to be mis-used in such a way as to place undue strain on the ligaments.

## Treatment

The pain is due to tension on abnormal ligaments and consequently there are two ways of relieving it—support the foot to prevent tension, or restore the ligaments to normal.

**Arch Supports.** These are used with the intention of preventing the foot everting, and of taking the weight of the body instead of allowing it to fall on the ligaments. Although they have certain uses, they are generally pernicious instruments because they prop up the foot in replacement of the muscles whose job it is and give the muscles no chance to recover. In time, movement is restricted still further, the feet become stiffer and finally supports cease to be of use.

Supports may legitimately be prescribed as a temporary measure when there is no ligamentous damage. The type of patient they help is the shop assistant whose feet ache after standing all day, but they should be worn only whilst at work, and only until muscle function has been restored. Supports may have to be used permanently when the muscles are unequal to the task imposed on them, as with very heavy people, and also when there is chronic arthritis and it is impossible to restore movement.

Supports should be light in weight and yet of a material strong enough to keep shape. Duralumin is satisfactory but a covering of felt or sponge rubber is desirable if the feet are tender. An accurate fit is essential, and although a stock size can sometimes be used, supports often have to be made specially. They should be shaped to the pattern of a plaster cast made whilst the foot is held in the corrected position, and the common practice of taking a cast whilst bearing weight in the valgus position, or of making the support to the shape of a footprint on a piece of paper, is unsatisfactory.

**Manipulation.** The purpose is to restore movement when it is restricted by new and painful scar tissue which has formed as the result of gross injury, repeated minor traumata or disease. Manipulation is not intended, as is often erroneously stated, "to break down the arch" of a

contracted foot. The force used should be sufficient to tear new scar tissue, but inadequate to injure the ligaments.

The indication for manipulation is pain at the extreme of active or passive movements at one or more joints. Generally speaking the more supple the foot, the better the prognosis. When there is chronic arthritis it may be possible to restore a useful range of painless movements, but it is better to repeat a gentle manipulation several times than to be so violent as to produce a severe reaction.



FIG 161 Manipulation of the foot—distraction of the subtaloid and ankle joints

An anæsthetic is generally required for manipulation. The foot is moved into full inversion and eversion, plantar- and dorsi-flexion. The method of distracting the subtaloid and ankle joints is illustrated in Fig. 161 : the patient's knee is flexed to shorten the distance between the thigh and heel and at the same time the operator's wrist is straightened.

After treatment consists in massage and active and passive movements continued until the injury has resolved. Proper muscle control is taught, and attention is given to any minor deformity or other condition that may have played a part in producing the strain.

## PERONEO-EXTENSOR SPASM

(*Synonym*) Spasmodic Flat Foot

This is a fairly common syndrome in which the foot is held rigidly in a position of valgus by spasm of the peronei and the long extensors of the toes. The ætiology is not fully understood ; although it is clear that the spasm is a reflex phenomenon, the cause of the spasm varies and it is probable that the syndrome will eventually be divided into several distinct conditions. The following observations have been recorded :—

(*a*) The presence of a calcaneo-navicular bar of bone in a fairly large percentage of patients.

(*b*) An injection of novocain into the talo-calcaneal ligament sometimes relieves the spasm suggesting that a disorder of this ligament may then be the responsible factor.

(*c*) A small erosion of the articular cartilage covering the talo-calcaneal or talo-navicular joints has occasionally been seen at operation and in such cases is probably the cause of the spasm.

*Calcaneo-navicular Bar* is a congenital anomaly in which the calcaneus and the navicular bones are joined together by a complete or partial bridge





FIG 162 Peroneo-extensor spasm in a boy aged 16 years, with a calcaneo-navicular bar in the left foot The right foot was normal

of bone (Fig. 162). It is probably due to an unusual degree of development of an accessory bone, the os calcaneus secondarius, that is present in some 2 per cent of people (p. 261). The anomaly can be demonstrated only in oblique radiographs, and it should be sought whenever there is peroneo-extensor spasm.

A calcaneo-navicular bar does not necessarily affect the shape of the foot, indeed it is probable that most feet with such a bar are normal during the early years of life. It appears, however, that the presence of the bar alters the mechanics of the foot making it more liable to strain, and then the increased stresses to which the feet are subjected during adolescence precipitate the onset of symptoms.

## Clinical Features

The acute phase occurs in adolescents of about fourteen to seventeen years of age, occasionally in younger children and only rarely in adults. It may be unilateral or bilateral, and boys are affected more often than girls. The onset is usually soon after starting work, or changing to an occupation involving standing or walking on a hard surface, hence the complaint is sometimes known as "apprentice's foot."

Pain is the chief complaint. At first it may be felt only towards the end of the day but it rapidly increases until walking, standing and bicycling are all painful. The foot is held in eversion and dorsiflexion by spasm of the affected muscles, and the long extensors stand out prominently in front of the ankle. Attempts to invert the foot passively increase the pain and spasm; sometimes the spasm can be inhibited voluntarily, but often it does not disappear entirely even during deep anæsthesia. X-rays may show a calcaneo-navicular bar, and at a late stage there is often lipping of the dorsal aspect of the talo-navicular joint.

Diagnosis must be made early because only then is there a chance of successful conservative treatment. In an untreated or unsuccessfully treated case, the deformity is permanent; pain and spasm may gradually decrease and finally disappear entirely, but within a few years osteoarthritic changes take place in the distorted joints and pain returns.

## Treatment

Treatment, to be successful, must be begun within a few weeks of onset; it is a waste of time after months. A light plaster is applied in the neutral, plantigrade position, an anæsthetic being given if relaxation cannot otherwise be obtained. Weight-bearing, even in plaster, is prohibited, but crutches may be used when only one foot is affected. The plaster is removed after two months and if there is then no spasm, massage and exercises are commenced, but weight-bearing is avoided for a further month; if the spasm returns, the plaster is re-applied. Operative section of a talo-calcaneal bar is seldom, if ever, successful in relieving the symptoms.

An injection of proctocain into the talo-calcaneal interosseous ligament sometimes relieves the spasm, presumably when this ligament happens to be the source of irritation (Ellis). The needle is inserted a little above and behind the sustentaculum tali and directed forwards at an inclination of about 45° into the sinus tarsi.

Stabilisation of the foot is necessary when there is no response to conservative treatment. Dunn's operation (p 464) may be used, but when there is no fixed deformity, the author finds it much simpler, equally successful, and a saving of the patient's time, to fix the sub-taloid and talo-navicular joints by means of cancellous bone grafts taken from the ilium and inserted into broad, deep channels cut across these joints from the inner side of the foot. Weight-bearing in a plaster cast is begun in two weeks and the plaster cast is removed after eight to ten weeks.

## CONGENITAL FLAT FOOT

This rare complaint is not classified with peroneo-extensor spasm, although muscle spasm and an extreme valgus position of the foot are characteristic features, because the ætiology, course and treatment are different. The cause is a congenital structural anomaly in the formation of the tarsus known as a talo-calcaneal bridge. The anomaly was first described by anatomists long ago, and the clinical condition also has been known for many years, but the two were correlated only in 1948 by R. I. Harris.

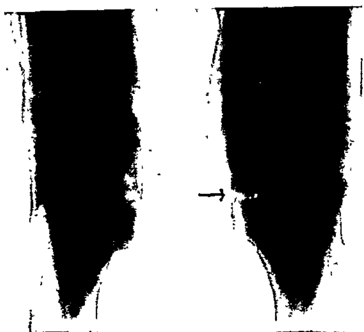


FIG 163. Talo-calcaneal bar.
*Left* X-ray of the left foot of the patient illustrated in Fig 164, showing talo-calcaneal synostosis.
*Right.* X-ray of a normal right foot for comparison. The arrow points to the joint between the talus and the calcaneus at the level of the sustentaculum tali.

The anomaly consists of a bridge of bone joining the posterior aspect of the sustentaculum tali of the calcaneus to the outer surface of the talus (Fig. 163). The bridge may be complete (synostosis), or it may be interrupted by a fibrous band (syndesmosis), or by a cartilaginous band (synchondrosis). It can be demonstrated radiologically by an oblique projection with the patient standing on the film with the knees slightly bent and the tube above the heels and pointing forwards 45°. In addition to the chief defect there is almost invariably lipping of the dorsal aspect of the talo-navicular joint, and sometimes a small ossicle is present at this site.

### Clinical Features

The presence of a bridge joining the talus and the calcaneus makes all movement between these bones impossible and therefore the normal

### Clinical Features

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Diagnosis must be made early because only then is there a chance of successful conservative treatment. In an untreated or unsuccessfully treated case, the deformity is permanent; pain and spasm may gradually decrease and finally disappear entirely, but within a few years osteoarthritic changes take place in the distorted joints and pain returns.

### Treatment

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## PAIN IN THE FOREFOOT

The causes of pain in the forefoot are :—

| | |
|---|---|
| *Outer four toes.* | *Anterior metatarsalgia.* |
| | *Morton's metatarsalgia.* |
| | *March fracture.* |
| | *Osteochondritis.* |
| *Big toe.* | *Sesamoiditis* |
| | *Lipoma.* |

Anterior metatarsalgia, a condition affecting the metatarso-phalangeal joints, is the usual cause of pain in the forefoot, and it must be sharply distinguished from Morton's metatarsalgia in which the pain is referred over the distribution of the digital nerves. Pain under the big toe is not due to the ordinary type of anterior metatarsalgia but is usually associated with disorder of the sesamoid bones.

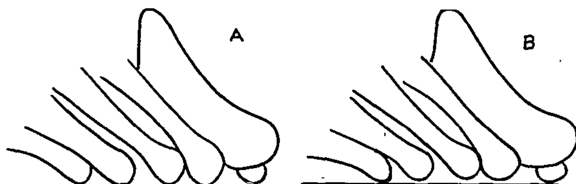



FIG 165 Tracings of the radiographs of a foot (A) when bearing weight, and (B) with no weight on it.

Anterior metatarsal pain is sometimes said to be due to stretching of the transverse metatarsal ligament, presumably because a splayed forefoot is often painful. The evidence, however, is against this theory : the pain is felt when wearing shoes tight enough to prevent the forefoot spreading, it is not increased by pulling apart the metatarsal heads, and the tenderness is over the metatarso-phalangeal joints, not over the interosseous spaces where the ligament is situated.

## ANTERIOR METATARSALGIA

**The Transverse Arch.** In cross-section the metatarsal and mid-tarsal bones are arranged in the shape of an arch which is highest at the base of the metatarsals, and gradually becomes more shallow until at the level of the metatarsal heads it has almost disappeared. It must be accepted as an anatomical fact that in normal circumstances there is no transverse arch at the level of the metatarsal heads, and although there may be a slight upwards curve when the foot is not bearing weight, the metatarsal heads certainly lie in the same horizontal plane when standing (Fig. 165). On the other hand, in some pathological conditions the line of the metatarsal heads becomes convex downwards.

movements of inversion and eversion are absent (p. 16). Deformity is probably slight in infancy but it increases during growth as the bridge gets longer and the calcaneus is forced into eversion; by the time growth is complete the foot is in a position of extreme valgus and the navicular and the head of the talus form a prominent bulge on the inner border (Fig. 164.)

Symptoms are unusual until adolescence or early adult life and then they resemble those of peroneo-extensor spasm. The onset is precipitated by unaccustomed use of the foot, e.g. marching; pain is felt whilst using the foot, and there is spasm of the peroneal muscles and the extensors of the toes. The diagnosis depends on the appearance of the foot, the length of the history and the X-ray findings.



Fig 164 Congenital flat foot" due to talo-calcaneal synostosis (cf Fig 162) The feet had been abnormal in shape since early childhood

## Treatment

Conservative treatment is without effect because the abnormal structure of the bones prevents correction of the deformity by any simple means. The best procedure is to perform a triple arthrodesis (p. 464), and this should be carried out as soon as the symptoms become troublesome because once the foot begins to hurt, pain and difficulty in walking continue indefinitely. The operation is successful in relieving pain; it is, however, technically difficult because of the presence of abnormal bar of bone and the great distortion of the tarsus, and it is not always possible to restore the shape of the foot to normal.

varus to avoid pressure on the painful spot; pressure on a painful corn may be avoided by deliberately curling up the toes; a hammer toe may depress a single metatarsal head below the level of its fellows; inability to dorsiflex the big toe (hallux rigidus) compels the weight to be transferred to the outer border of the foot; or a short first metatarsal may cause too much weight to be taken by the second metatarsal which is not suitably constructed for this purpose.

**Trauma.** Sometimes a specific injury can be blamed for the onset of metatarsalgia, for example treading heavily on a small stone when walking in thin-soled shoes.

**Unsuitable Shoes.** Shoes that are too short cause the toes to be curled up, and those that are too tight may cause corns, or they may force the metatarsal heads into a curve, convex downwards. The most harmful

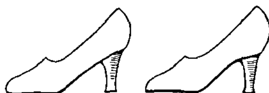


Fig 166 A high-heeled shoe should have a nearly horizontal platform on which the heel can rest

shoes are those constructed with a high heel and no platform on which the weight can rest; there is then an inclined plane sloping from the back of the heel to the tread and the foot slides forwards crushing the metatarsal heads together and curling up the toes (Fig. 166). It is not the height of the heel that matters, but the absence of a platform to rest on.

## Symptoms and Signs

Anterior metatarsalgia occurs at any age but most often in middle life when there is a tendency for muscle tone to decrease. Any of the outer four metatarso-phalangeal joints may be affected, and often more than one at a time. The onset is usually gradual, but it may be sudden when caused by a definite minor injury, or by wearing new shoes. Pain is felt at first in the affected joints, but later it radiates over the foot and sometimes up the calf. It varies in intensity from time to time but it tends to get progressively worse, and it may become so severe as to prevent walking except on the heel.

On examination, there is tenderness over the distal aspect of the affected metatarsal head when it is uncovered by dorsiflexion of the toe, and often over the plantar and dorsal aspects also. Acute pain is caused by passive plantar flexion of the metatarso-phalangeal joint. There may be swelling of the joint visible on the dorsum of the foot, and *perhaps some* superficial œdema. In old-standing cases the ball of the foot becomes convex and painful callous forms under the prominent *part (Fig. 167)*. Absence of the normal longitudinal crease between the first and second metatarsals is a constant finding when there is long-standing intrinsic muscle dysfunction.

## Ætiology

Anterior metatarsalgia is a painful condition affecting one or more of the outer four metatarso-phalangeal joints, and it is usually caused by faulty distribution of weight on the forefoot.

The first metatarsal bone is large and strong, and the metatarso-phalangeal joint is protected by two sesamoid bones. The four outer metatarsals are slender bones, ill-adapted for carrying weight; the metatarso-phalangeal joints are correspondingly small and do not usually have sesamoids. The whole body weight does not ordinarily rest on the outer metatarsals alone. When walking the weight is transferred from the heel to the outer border of the forefoot and then immediately to the inner border; during the phase of "take-off" it is mostly carried by the big toe. When standing, the outer metatarsals assist in keeping the balance but do not take much of the weight. If for any reason an excessive amount of weight is habitually carried on the outer metatarsals, these ill-protected joints are injured. The joint capsule, synovial membrane and articular cartilage are bruised, and in time chronic inflammatory changes take place, the capsule becomes thickened and the periarticular tissues inflamed.

The principle causes of faulty distribution of weight in the forefoot are:—

*Intrinsic muscle dysfunction.*
*Minor deformities of the foot.*
*Trauma.*
*Unsuitable shoes.*

**Intrinsic Muscle Dysfunction.** The interosseous muscles function in such a way as to protect the metatarso-phalangeal joints. When they contract they flex the metatarso-phalangeal joints and extend the inter-phalangeal, and in addition they draw together the metatarsal heads, an action which is re-inforced by the transverse muscles. The interossei contract during the final phase of each step and prevent the forefoot splaying as the weight comes onto it, and they prevent the toes curling up when the long flexors and extensors contract (p. 228). Failure of the intrinsic muscles therefore permits two defects to develop—the forefoot spreads and the toes curl up. When the toes are curled up, the proximal phalanges are above the metatarsal heads and pointing upwards; the metatarsal heads are therefore forced downwards making them more prominent in the ball of the foot, and more exposed to trauma.

Intrinsic dysfunction is nearly always present in anterior metatarsalgia either as the cause, or as the result. It is the cause in such conditions as pes cavus, hallux valgus, or muscular weakness following a long illness. It is the result because the conscious reaction to anterior metatarsal pain of whatever origin is to curl the toes in an endeavour to lift the metatarsal heads from the ground, and to do this the intrinsics must be inhibited.

**Minor Deformities.** These interfere with the proper distribution of weight in a number of ways of which the following are examples. When the deformity, say a bunion, is itself painful, the foot may be twisted into

tional exercises, which are still practised in many clinics, make use of quite the wrong muscles.

The patient should be taught to contract the interosseous muscles each time the forefoot touches the ground thus straightening the toes and preventing the forefoot spreading. First he acquires voluntary control over the muscles; with the foot flat on the ground, the effort is made to lift up the central metatarsal heads without curling the toes, and without raising the inner border of the foot. When the movement is made properly the forefoot becomes narrower, the toes extend at the interphalangeal joints and flex at the metatarso-phalangeal joints, and the central metatarsal heads are slightly raised (Fig. 169). Electrical stimulation of the muscles may help in learning this movement. Once there is complete voluntary control it is not difficult to learn to contract the muscles at each step immediately the ball of the foot touches the ground, and after a time the action becomes reflex.

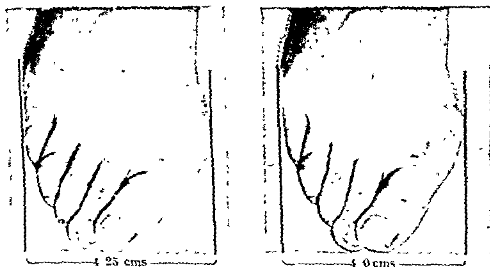



FIG 169 Contraction of the interosseous muscles makes the forefoot narrower and lifts up the middle three metatarsal heads The illustration is about one quarter scale showing that the foot has become 1 cm narrower

Other exercises are better avoided, particularly those making use of the long muscles which cause the toes to curl; they are not essential and patients so often do the easy exercises regularly and forget the harder ones. The object of treatment is to condition a reflex and the patient's attention should be directed towards this alone.

## MORTON'S METATARSALGIA

T. B. Morton in 1876 described a form of metatarsalgia which he attributed to the digital branches of the plantar nerves being crushed between the metatarsal heads. For many years afterwards all types of metatarsalgia were included in this category but the true syndrome is relatively uncommon and the diagnosis fell into disrepute. It was only when Betts described the true pathology in 1940 that attention was again directed to the problem, and since then the work of Bickel and Dockerty and of Nissen have placed it beyond doubt.

## Treatment

The painful joints respond, as elsewhere in the body, to rest and physiotherapy. Recurrence is, however, probable unless the primary cause can be removed and this is possible in many instances, specially when there is a deformity that can be corrected by operation.

Patients with severe pain and swollen joints need an initial period of rest in bed. Milder symptoms are often relieved by a pad of thick chiropodists' felt (zinc oxide felt plaster) placed immediately proximal to the painful joints, not beneath them (Fig. 168). The pad should be about two-thirds the breadth of the foot, cut square in front and tapered behind ; the front edge is left vertical but the others are champfered. The forefoot and



FIG 167 Hallux valgus with intrinsic muscle dysfunction The ball of the foot is convex and there is metatarsalgia affecting the second, third and fourth metatarso phalangeal joints

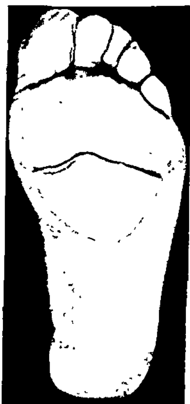


FIG 168 To relieve pressure on the metatarso-phalangeal joints, a pad of zinc oxide felt plaster is placed immediately *proximal* to them

pad are encircled firmly, but not tightly, with a strip of one-inch adhesive plaster. An elastic garter with pad attached, or an insole with an anterior metatarsal pad, are used when a permanent fitting is required.

Intrinsic muscle re-education is an essential part of treatment and cure is unlikely unless proper muscle function can be restored. When operative correction of a deformity is necessary, re-education should precede as well as follow operation. Re-education is not very difficult, except when the foot is grossly mis-shapen, but unfortunately the tradi-



FIG 171 March fracture of the third metatarsal

On examination, there is tenderness which is accurately localized to some part of the shaft of the metatarsal (*not* the metatarso-phalangeal joint), and there may be œdema of the dorsum of the foot. The clinical finding of tenderness over the shaft of a metatarsal is sufficient to demand X-ray examination, and if no bony change is shown at the first examination, it should be repeated after a week or two.

The radiological appearance depends on the stage at which examination is made. For a few days after the onset of symptoms the bone looks normal; the first change is a little roughening of the metatarsal shaft, and during the next few weeks a fusiform deposit of new bone is laid down. Usually, but not invariably, a line of "fracture" runs across the metatarsal, and occasionally across the new bone also; sometimes the "fracture" can be distinguished before the new bone appears, but often not till afterwards. The final appearance is that of transverse fracture in perfect position with profuse callus formation (Fig. 171).

**Treatment.** There is no tendency to displacement of the "fracture" and splinting is unnecessary. If the pain is severe, complete rest from weight-bearing may be necessary for a week or two, but it is usually sufficient to strap the foot firmly and avoid excessive walking. The symptoms subside spontaneously in three to six weeks from the time new bone is first seen and full activity can then be resumed. Radiological return to normal takes much longer and need not be awaited.



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## OSTEOCHONDRITIS OF THE METATARSAL HEADS

(*Synonyms*) Freiberg's Disease, Köhler's Second Disease

This is an uncommon complaint which affects the metatarsal heads, most frequently the second, less often the third and rarely the others. Many writers consider the condition belongs to the group exemplified by Perthes disease of the hip, but others think it is similar to osteochondritis dissecans of the knee. It is probable that both are right and there are really two varieties of the disease.



FIG 172 Osteochondritis of the second metatarsal head of the usual type



FIG 173 Osteochondritis of the second metatarsal head At operation a condition was found that resembled osteochondritis dissecans

The onset is during adolescence and the symptoms are pain, tenderness, stiffness and swelling of the metatarso-phalangeal joint. The X-rays at first show irregular areas of condensation and rarefaction in the epiphysis. The contour of the head gradually alters; it becomes broader and the outline of the articular surface appears S-shaped. The distal portion of the metatarsal shaft may become considerably thicker and broader than normal (Fig. 172). In the type resembling osteochondritis dissecans (Fig. 173) an area of articular cartilage and the underlying bone separate and may become detached to form a loose body.

**Treatment.** Rest is indicated in the early stages, if necessary in bed to start with, but later in a walking plaster. The symptoms may subside after a while, but if osteoarthritic changes take place later, the toe becomes stiff and the pain returns. It may then be necessary to excise the metatarsal head.

## PAIN UNDER THE BIG TOE

**The Sesamoids.** The ordinary type of anterior metatarsalgia does not occur at the first metatarso-phalangeal joint because it is protected by two sesamoid bones. Pain does, however, arise in connection with the sesamoids, even in the absence of deformity of the big toe. The trouble is frequently traumatic and then it may be caused by a minor injury like treading on a loose stone, or by more serious violence. Osteoarthritis of the joint between the sesamoids and the under surface of the metatarsal head may also be a cause of pain.

The pain, sometimes very severe, is felt under the joint when walking. Tenderness can be localized to one or other of the sesamoid bones by careful palpation. X-rays may be misleading because fracture of a sesamoid is rare, but symptomless congenital abnormalities in which the bone is divided into two or more parts (bipartite or tripartite sesamoids) are common and then the appearance somewhat resembles a fracture (Fig. 173).

Conservative treatment of painful sesamoids is usually successful, but often very slow. Little more can be done than relieve pressure by a felt pad placed proximal to the joint, but diathermy sometimes appears helpful. Very occasionally it is necessary to excise one of the sesamoids; both bones should never be removed or a most painful joint is produced which is quite unable to take any weight.

**Lipoma.** A tender and painful lipoma is sometimes found in the subcutaneous tissues under the first metatarsal head. It is usually encapsulated and readily removed; its importance lies in the fact that it displaces the normal fibro-fatty tissue and, after removal, nothing is left but skin to cover the joint. The thick subcutaneous tissues act as a shock-absorber and without this covering the joint soon becomes painful. Subsequent to the removal of a lipoma, a cupped sorbo pad should be provided to protect the joint, and it should be worn until the subcutaneous tissues have re-formed.

## OSTEOCHONDRITIS OF THE NAVICULAR

(*Synonym*) Kohler's Disease

This condition resembles osteochondritis juvenilis in other bones and probably has a similar pathology (p. 140). It occurs more frequently in boys than girls, and at any age between three and ten years with a maximum incidence from four to six years. It is occasionally bilateral. The child complains of pain at the inner side of the foot, and he limps. On examination, there is tenderness over the navicular bone and sometimes a little swelling.

Similar symptoms occurring in older children or adults may be due to the presence of an accessory bone situated at the tuberosity of the navicular (*os tibiale externum*), or to strain of the insertion of the tendon of the tibialis posterior.

The X-ray changes in Köhler's disease are characteristic (Fig. 174). The centre of ossification is increased in density, it is often irregular in

outline, and it may be divided into two or more parts. The bone appears to be flattened and compressed antero-posteriorly.

**Treatment.** The disease runs a course lasting from one to two years after which the structure of the bone returns to normal. There may be some permanent distortion of shape but this does not appear to cause later symptoms. Treatment has no effect on the course and the pain nearly always subsides spontaneously within a few months even though the radiological appearances remain abnormal.



FIG 174 Köhler's disease of the tarsal scaphoid *Left* Shortly after the onset of symptoms *Right* Ten months later

Some relief from pain is given by strapping the foot in inversion. Walking and games should be avoided as far as possible, but it is seldom necessary to keep the child from school. Occasionally the pain is severe enough to call for a walking plaster. Normal use of the foot is permitted as soon as the symptoms have subsided.

## PES CAVUS AND CLAW TOES

Pes cavus in most instances is accompanied by clawing of all the toes, including the big toe. The high-arched appearance is due not so much to true raising of the arch as to dropping of the forefoot at the intertarsal and tarso-metatarsal joints. The posterior part of the foot is normal and the calcaneus is in its ordinary position relative to the talus and tibia (Fig. 175).

The cause, as was recognized many years ago by Duchenne, is to be found in dysfunction or paralysis of the interosseous and lumbrical muscles, and the short flexors and abductors of the big toe. This may be due to disease of the central nervous system, for example anterior poliomyelitis, the hereditary ataxias and peripheral nerve injuries. As a rule, however, it is not caused by gross disease, but by lack of proper co-ordination of the intrinsic muscles (*idiopathic type*).

The mechanism by which the deformity is produced is as follows: the interphalangeal joints are flexed by the long flexors

the interossei; the metatarsophalangeal joints are flexed by the interossei and extended by the long extensors (Fig. 258, p. 331). Normally, these muscles function synergically, the intrinsics preventing flexion at the interphalangeal joints when the long flexors contract during the "take off" phase in walking. If the intrinsics are inadequate, the long muscles are unopposed and the toes become clawed; the proximal phalanges, which then point more or less directly upwards, are displaced on to the dorsum of the metatarsal heads, and the latter are forced downwards. When this occurs before growth has ceased, the shape of the foot is permanently distorted.

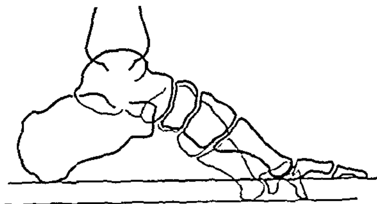


FIG. 175 The deformity in pes cavus.

An uncommon but severe type of pes cavus, usually without clawing of the toes but accompanied by changes in shape of the posterior part of the foot, is caused by paralysis of the triceps suræ. The foot is drawn into strong dorsiflexion at the ankle by the unopposed action of the extensors; the calcaneus is distorted and points obliquely upwards, and the forefoot is angled sharply downwards at the inter-tarsal joints. A similar appearance is sometimes found in congenital talipes calcaneo-cavus.

## Symptoms

The "idiopathic" type usually commences during childhood, and the first sign is clawing of the toes, sometimes of big toe only, but often of all the toes. It is impossible to give a prognosis at this stage; there may be spontaneous arrest with only trivial deformity, or there may be steady deterioration until growth is complete. At first the deformity can be corrected passively, but in time the muscles and fascia in the sole of the foot and on the plantar aspect of the toes contract and the deformity becomes fixed (Fig. 176). When the deformity is severe it is impossible to dorsiflex the ankle sufficiently to get the heel to the ground. The toes are sometimes dislocated dorsally at the metatarso-phalangeal joints.

There is seldom pain in childhood but complaint may be made of the rapidity with which shoes are worn out. At a later stage pain is caused by the abnormal amount of pressure that has to be taken by the ball of the foot. This causes severe anterior metatarsalgia, and most intractable corns and callosities develop on the dorsum of the toes and under the

metatarsal heads. There may also be pain in the mid-tarsal region caused by the strain on that part of the foot.

In adults, the gradual development of pes cavus is usually indicative of the onset of disease of the central nervous system. The recognition of this is important because all forms of operative treatment may be contraindicated (except in Friedreich's ataxia developing during adolescence when operation is often helpful (p. 471).

## Treatment

In the "idiopathic" type, before the deformity is fixed, it may be possible to arrest progress by re-educating intrinsic muscle function by the method described for anterior metatarsalgia (p. 222). Shoes without heels, but having stout leather soles, should be worn to force up the forefeet.

After the deformity is fixed, treatment may be palliative or operative—either shoes are made to fit the feet, or the feet are made to fit ordinary shoes.



FIG 176 Pes cavus in a boy aged 14 years.

**Footwear.** Special shoes will not arrest the development of the progressive type of disease but they do give tolerable comfort to most patients. They must be made with ample room both for the deformed toes and for a moulded cork insole. The insole should be thick enough at the heel to allow for the dropped forefoot, curved to fit the instep, and have a slight thickening to take the pressure just proximal to the metatarsal heads. A steel inserted between the welt and sole may prevent the sole of the shoe from arching and breaking.

**Operation.** *An operation, to be satisfactory, should both correct the existing deformity and prevent its recurrence.*

LAMBRINUDI'S OPERATION redistributes muscle power in such a way as to fulfil these requirements. It consists in arthrodesis of all the interphalangeal joints of all the toes, including the big toe. By this means the action of the long flexors and extensors is transferred from the interphalangeal to the metatarso-phalangeal joints; clawing is corrected, the toes are restored to their proper alignment with the metatarsals and downward thrust on the metatarsal heads is eliminated. The stiff interphalangeal joints cause

little inconvenience, and as a rule the cavus gradually disappears and the foot returns to a normal shape.

The operation is satisfactory in children and adolescents but less so in adults because the tarsal bones are unable to adapt themselves to their altered positions. It is contra-indicated when there is actual dislocation at the metatarso-phalangeal joints. When the deformity is slight and affects only the inner border of the foot, it may be sufficient to arthrodese the interphalangeal joint of the big toe only.

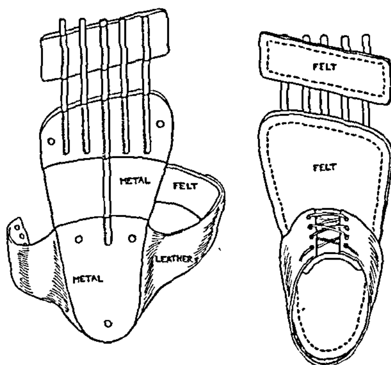



Fig 177 Sole plate for use after Lambrinudi's operation (Reproduced by permission from Burns and Ellis "Recent Advances in Orthopædics")

Bony union at the small terminal interphalangeal joints is not easy to obtain but Lambrinudi's technique gives a high percentage of successes. After simple transverse excision of each joint, the toes are fastened to a special sole plate by salmon-gut stitches passed around the proximal phalanges and emerging through the skin of the plantar surface just distal to the web (Fig. 177). The stitches are left for six weeks and then all fixation is removed and walking commenced. Rehabilitation is slow and requires the co-operation of the patient.

Steindler's operation consists in detaching the muscles, ligaments and fascia arising from

*wrench; the muscl*

The operation gives a good immediate result and the period of incapacity is short, but recurrence of deformity is common because the cause is not removed. It is, however, valuable if there is not much deformity and the intrinsic muscles are reasonably good. Sometimes it can usefully be combined with Lambrinudi's operation.

## HALLUX VALGUS

This is the commonest of all the deformities of the feet. A trivial degree is so often seen amongst adults of western races that it can hardly be called abnormal, but the more severe deformities give rise to much suffering.

*The cause is difficult to determine. The condition is often familial and* grandparents, parents and children may all be afflicted. Women are affected with much greater frequency than men, and if hereditary transmission does in fact occur, it appears to be chiefly, but not exclusively, on the female side. The metatarsus varus element of the deformity is usually pronounced *in familial cases, and often the first metatarsal is short as well. It has been*

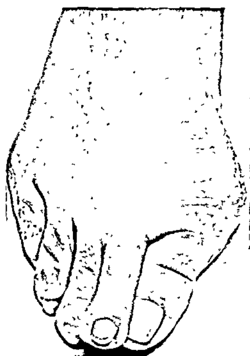


FIG 178 Hallux valgus in a young woman There is marked metatarsus primus varus, but only a moderate amount of valgus of the phalanges, the symptoms were restricted to the bunion

estimated that in about 5 per cent of patients the deformity is first noticeable in early childhood, and the percentage increases steadily until the 'teens.

The classical explanation of hallux valgus is that the toes are pressed out of position by wearing tight or pointed shoes, or tight hose. In recent years there has been marked improvement in the design of children's footwear and an increasing awareness amongst parents of its importance, but no corresponding decrease in the incidence of hallux valgus. The footwear theory *clearly cannot account for the varus first metatarsal, and it is* very doubtful if it is of importance even when this element of the deformity is small. Nevertheless, shoes may play some part in the ætiology because hallux valgus is uncommon in races that go unshod, and it might be that wearing shoes interferes with the natural use of the intrinsic muscles.

Factors tending to increase the deformity after deflection of the toe has commenced are (1) the direction of thrust when walking with the foot turned slightly outwards, (2) wearing shoes, because this removes the need for the "gripping" action of the toes which is present when barefooted, (3) displacement of the flexor and extensor tendons towards the outer side of the metatarso-phalangeal joint thus making their pull eccentric.

## Pathological Anatomy

The principal features are :—

1. Varus (or inward) deflection of the first metatarsal at the tarso-metatarsal joint ; it is usually pronounced in familial cases and is often present in others. Not infrequently the outer four metatarsals are also



FIG 179 Hallux valgus Note the varus deformity of the first metatarsal.

deflected inwards, but to a lesser extent than the first. The gap between first and second metatarsals is filled with fibro-fatty tissue (*Fig. 179*).

2. Valgus (or outward) deflection of the phalanges at the metatarso-phalangeal joint. Slight to start with, the displacement increases and sometimes reaches the extreme stage in which the phalanges form an angle of 90° with the first metatarsal and lie transversely across the proximal phalanges of the other toes. The joint capsule becomes lengthened on the inner side and contracted on the outer. The toe is often rotated inwards about its long axis, and sometimes there is also a valgus deformity at the interphalangeal joint, particularly when the joint abuts on a clawed second toe around which it appears to curl (Fig. 180).

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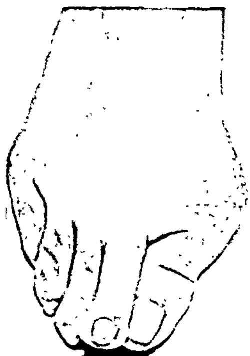


FIG. 178. Hallux valgus in a young woman. There is marked metatarsus primus varus but only a moderate amount of valgus of the phalanges. The symptoms were restricted to the bunion.

estimated that in about 5 per cent of patients the deformity is first noticeable in early childhood, and the percentage increases steadily until the 'teens.

The classical explanation of hallux valgus is that the toes are pressed out of position by wearing tight or pointed shoes, or tight hose. In recent years there has been marked improvement in the design of children's footwear and an increasing awareness amongst parents of its importance, but no corresponding decrease in the incidence of hallux valgus. The footwear theory clearly cannot account for the varus first metatarsal, and it is very doubtful if it is of importance even when this element of the deformity is small. Nevertheless, shoes may play some part in the ætiology because hallux valgus is uncommon in races that go unshod, and it might be that wearing shoes interferes with the natural use of the intrinsic muscles.

### Symptoms

The pain does not vary pari passu with the severity of the deformity, and sometimes there is gross deviation of the toe with but little trouble whilst a minor degree may give rise to disabling pain. The symptoms are of two categories—those due to the bunion and those due to secondary deformities and metatarsalgia.

The bunion is painful when pressure and friction against the side of the shoe cause it to become inflamed; the bursa distends with fluid and often a small but very tender corn develops in the overlying skin. The amount of pain depends on these factors and not on the degree of deformity. Infection not infrequently follows a neglected abrasion or the patient's own attempts to remove the corn; the skin becomes inflamed and the bursa may suppurate, but only rarely does infection spread to the bone or joint.

Metatarsalgia and secondary deformities such as hammer toe may be the chief cause of the pain. They give rise to the same symptoms as when due to other causes. With old standing, severe deformities the forefoot is splayed, there are callosities under the metatarsal heads and corns on the dorsum of the toes, the spring is lost from the gait and the sufferer hobbles about in a painful and ungainly way.

### Treatment

**Conservative.** Patients with symptoms limited to the bunion can often be kept free of pain. The corn is removed using an aseptic technique, and pads of zinc oxide felt plaster are arranged round the swelling to relieve pressure. The fluid is eventually absorbed and it may be possible to prevent further trouble by careful selection of footwear. "*Bunion protectors,*" *which can be obtained from many chiropodists,* give good protection from pressure.

When the deformity is slight but metatarsalgia is pronounced, it is tempting to disregard the deformity and treat the metatarsalgia conservatively, but this is seldom successful until after the big toe has been straightened. In severe, old standing deformities the disorganization of function is such that nothing can restore the foot to normal; reasonable comfort can, however, be given by a combination of operation, metatarsal pads and special shoes.

**Operation.** This has a bad reputation amongst the public, but properly performed it gives consistently good results and brings more thanks to the surgeon than almost any other. The operation is really an arthroplasty, an arthroplasty of a weight-bearing joint, and yet there is a tendency to regard it as a minor procedure! *Careless work* with some operations may mean only a few weeks longer spent in convalescence, but the unskilled correction of a hallux valgus leaves a cripple for life.

The indications for operation are :—

3. The big toe may lie over or under the second toe, or the second toe may escape pressure by curling up. Soft corns and infection of the nail bed often occur where the toes are in contact. The second toe may be displaced upwards by the big toe to such an extent that it dislocates dorsally at the metatarso-phalangeal joint ; this is quite a common occurrence and it can readily be detected on clinical examination (Fig. 180).

4. The extensor tendon is displaced towards the outer side of the metatarso-phalangeal joint. The sesamoids tend to restrain the flexor tendon from similar displacement because they lie in grooves under the metatarsal head, but they often move outwards a considerable distance.



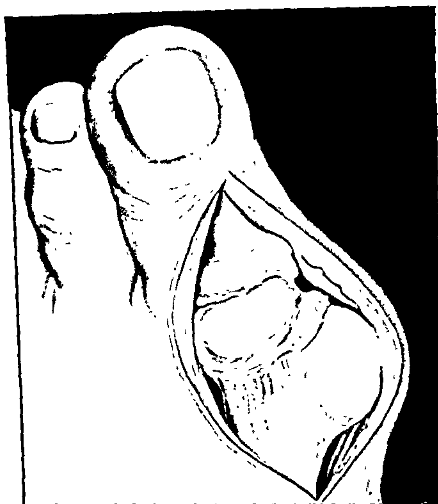
Fig. 180 Hallux valgus with dorsal dislocation of the metatarso-phalangeal joint of the second toe

5. The articular cartilage covering the metatarsal head is eroded where it is exposed by displacement of the phalanx. There is often a groove forming a line of demarcation between the exposed and covered cartilage (Plate II).

6. An exostosis forms on the inner side of the metatarsal head. Often a bursa (or bunion) containing gelatinous material forms over the exostosis, and a painful corn develops in the overlying skin. The bony prominence on the inner side of the joint consists partly of the exposed metatarsal head and partly of the exostosis.

7. The deformity interferes with the proper function of the intrinsic muscles and the ball of the foot becomes convex giving rise to anterior metatarsalgia. Clawing and dislocation of the second toe depress the corresponding metatarsal head and also cause metatarsalgia.

PLATE III



Hallux Valgus as displayed at operation.

1. Pain due to pressure on the inner side of the joint.
2. Anterior metatarsal pain.
3. Painful deformities of the other toes.
4. Correction of metatarsus varus is sometimes desirable in children.

Operation should never be performed for cosmetic reasons alone and careful selection of patients is important. A good result giving almost perfect function can be relied on when the general function of the foot is good, but only partial relief is possible if the whole foot is grossly deformed; between these extremes is a whole range of varying prognosis. Some judgment is necessary when deciding what benefit is likely to follow operation and it is wise to give the patient an accurate and not unduly optimistic forecast.

The conservative operation of removing only the bunion and underlying exostosis is a comparatively minor proceeding but of limited application. The bunion is dissected from the skin, the joint opened and the inner portion of the head of the metatarsal removed as far as the line of demarcation between the exposed and covered parts of the articular cartilage (Plate III). This procedure may give relief for some years provided the deformity is slight and the symptoms are strictly limited to the bunion, but it does not help when there is gross deformity or when there is anterior metatarsalgia; nor does it prevent subsequent increase in the valgus deformity, and the patient should be both warned of this, and told that the bunion may recur in the course of time.

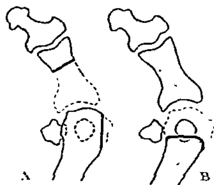


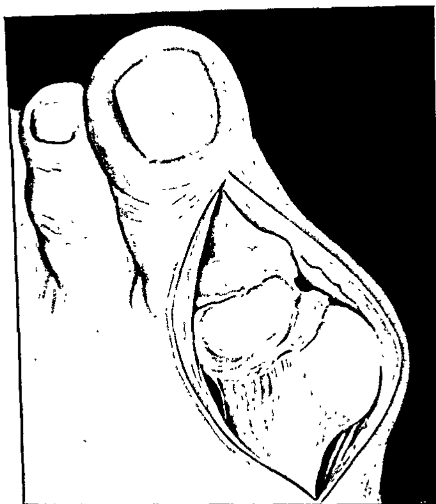

FIG 181 Operations for Hallux valgus based on (A) Keller's procedure, (B) Mayo's procedure

There are two types of radical operation each with its advocates who employ it as a routine procedure (Fig. 181). In *Keller's operation* the proximal two-thirds of the proximal phalanx of the big toe is excised together with the bunion and inner part of the metatarsal head. In the modified *Mayo's operation*, the proximal phalanx is not disturbed but the distal part of the metatarsal head is removed. The amount removed varies slightly in the individual, but it is usually about five-sixths of the head; if too much is taken away, the sesamoids are left without support and the result is a painful foot of the most intractable type.

A careful technique with a minimum of unnecessary trauma is essential. It is particularly important to dissect the flexor and extensor tendons from the bone in such a way that they are not exposed or they will later adhere to it. Damage to the sesamoid bones must be avoided, especially if they are already osteoarthritic, or they also will become adherent. If the bunion is infected, it should first be drained or dissected out and the major operation postponed for some weeks.

After-treatment needs as much care as the operation itself. The author prefers Keller's operation and afterwards bandages the toe so as to hold

PLATE III



Hallux Valgus as displayed at operation.

[To face page 236

it slightly inwards and downwards. Passive movements to the extent permitted by the dressings are commenced on the third day. The dressings and stitches are removed on the tenth day and active movements begun, but weight-bearing is avoided until the fourteenth day after unilateral operations, and the twenty-first day after bilateral. The patient must make the effort to walk correctly from the start and to take the weight on the ball of the big toe even if it hurts—no hobbling allowed. Intrinsic re-education as described for metatarsalgia is absolutely essential when there is anterior metatarsal pain. Constant supervision is necessary for a couple of months to ensure that movement of the toe is maintained and the intrinsic muscles are properly used. Most patients are able to return home and walk without too much discomfort a few days after they get up, and then there should be steady improvement for two or three months when complete freedom from pain may be expected.

**Secondary Deformities.** Correction can usually be carried out at the same time as the big toe. Hammer toe and mallet toe are straightened by the usual methods (q.v.). Dorsal dislocation of the second toe cannot be reduced but excision of the entire proximal phalanx gives a satisfactory result. The second toe should never be amputated or the big toe, left without support, deviates further and causes the third toe to become deformed.

Valgus deformity at the interphalangeal joint of the big toe occurring alone or at the same time as hallux valgus occasionally requires correction. This is done by arthrodesis of the interphalangeal joint; bony union is slow after simple excision of the joint and a "step" operation or a bone graft is desirable.

**Children.** Advice as to treatment for early deformity in children is often sought but it is not easy to give because, unless the metatarsus varus can be corrected, there is little hope of preventing deviation of the phalanges. Remedial exercises appear to have little affect; some children have even learnt to abduct the big toe actively and practised it constantly for years, but without benefit.

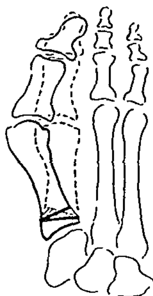


FIG 182 Operation for metatarsus primus varus in children

Operation may be recommended when the deformity increases over a period of years and is obviously going to be severe later in life. The optimum age is between ten and fourteen years; the operation is not satisfactory if performed after growth is complete. The fibro-fatty tissue is removed from the first metatarsal space and the capsule excised at the outer side of the metatarso-phalangeal joint to allow correction of the valgus. The alignment of the first metatarsal is corrected by removing from its proximal end a wedge of bone with the base outwards and replacing it with the base inwards (Fig. 182). The foot is fixed in plaster-of-Paris for about eight weeks when union should be secure.

## HALLUX RIGIDUS

The normal range of dorsiflexion at the metatarso-phalangeal joint of the big toe is about 90°; when walking ordinarily the toe dorsiflexes between 20° and 30° during the "take off" phase, and rather more when walking fast or running, or when wearing high-heeled shoes. When dorsiflexion is limited the condition is known as hallux rigidus; there are two varieties, acute and chronic.

### Acute Hallux Rigidus

This type is rather uncommon and is seen chiefly in adolescents with long narrow feet, and only rarely in adults. Not infrequently it is bilateral. Trauma, such as stubbing the toe or wearing shoes that are too short, is probably an ætiological factor, but some cases may be associated with focal sepsis.



FIG 183 Method of applying extension in acute hallux rigidus

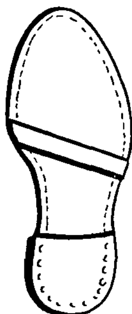


FIG 184 Outside metatarsal bar.

The pathological condition varies; sometimes the articular cartilage is bruised, sometimes the synovial membrane and periarticular tissues are inflamed, and sometimes there is tenosynovitis of the extensor hallucis longus. The patient complains of severe pain on using the foot, walking is difficult, and even the pressure of the bedclothes hurts. Examination shows that the toe is held rigid by muscle spasm, there is tenderness over the metatarso-phalangeal joint, and sometimes over the tendon of the long extensor.

**Treatment.** The condition must be taken seriously because if it is neglected, the articular cartilage is destroyed and the joint will almost certainly become permanently stiff. The longer treatment is delayed, the smaller is the chance of success.

The chief indications are to rest the joint and to relieve the joint surfaces from the pressure caused by muscle spasm. A plaster cast is applied from below the knee to the tip of the toes and a wire hook incorporated so that it extends about 6 inches beyond the big toe; elastic extension is attached to the toe by adhesive plaster (Fig. 183). Extension is maintained for four to six weeks during which time spasm usually disappears. If there is residual limitation of movement, a walking plaster is worn for another month, and afterwards the joint should be protected for a considerable time by a metatarsal bar fixed to the outside of the shoe (Fig. 184).

## Chronic Hallux Rigidus

This is the common type which occurs chiefly in adults, in men more frequently than women, and particularly in footballers and in individuals with an extra long big toe. It is frequently bilateral. Trauma may be an



Fig 185 Hallux rigidus

ætiological factor; sometimes it is possible to incriminate a single blow, but more often there are repeated minor injuries. Chronic symptoms also follow neglected acute hallux *rigidus*.

The pathological changes are those of osteoarthritis (Fig. 185). The articular cartilage on the metatarsal head is eroded and osteophytes form around it, chiefly on the dorsal surface but also on the inner and outer aspects. Similar changes often occur at the base of the proximal phalanx and in the sesamoid bones. A bursa may form over a projecting osteophyte

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FIG 183 Method of applying extension in acute hallux rigidus

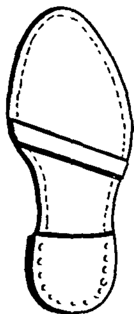


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## GOUT

Gout is now a rare complaint as compared with the time when it was so graphically described by Sydenham, but it does still occur and it is as likely to be encountered in a teetotaller or moderate drinker as in a heavy drinker. Men are affected almost exclusively but women appear to be able to transmit a predisposition to the disease. The big toe is the usual



Fig 187 Gout showing deposits in the head of the first metatarsal, the proximal phalanx of the big toe and the subcutaneous tissues at the outer border of the foot

joint to be attacked but other joints, specially small joints, may be affected. The reasons given by the older writers for the particular susceptibility of the big toe are its greater liability to injury, and the sluggish circulation around the joint which permits the deposit of crystals of sodium biurate.

Attacks of acute gout come on suddenly, often during the night when the patient is awakened by pain. The pain increases rapidly in intensity and becomes so extreme that the slightest jar is excruciating. There is œdema round the joint and the skin is tense, shiny and of a characteristic dull red colour. The joint is very tender and all movement most painful.

and cause a great deal of pain. Compensatory movement often develops at the inter-phalangeal joint which acquires a range of dorsiflexion of 60° to 90°.

**Symptoms.** Pain does not vary exactly with the amount of stiffness Some people have quite stiff big toes all their lives without any symptoms, but others get pain whilst there is still considerable movement. The patient illustrated in Fig. 186 had a rigid toe but no symptoms except from the pressure of the bursa on the shoe.

The toe usually stiffens gradually and the patient learns to dodge the lack of movement when walking partly by rolling onto the outer border of the foot, and partly by dorsiflexion at the interphalangeal joint. The final position of the toe may be such that it is flat on the ground when standing, but sometimes it is plantar flexed and the metatarso-phalangeal joint is raised from the ground. There is seldom an associated valgus deformity.



FIG 186 Hallux rigidus with a large exostosis on the dorsum of the first metatarsal head

The onset of pain is often precipitated by a minor injury, but once established it persists indefinitely. The actual cause of the pain varies; it may be due to movement of the osteoarthritic joint, to weight-bearing on osteoarthritic sesamoid bones, pressure on an exostosis or bursa, strain on the interphalangeal joint, or to callous on the skin under the joint. Anterior metatarsal pain caused by walking on the outer border of the foot is often the outstanding symptom.

**Treatment.** Some relief may be given by a metatarsal bar fastened to the sole of the shoe to act as a rocker and replace the movement of the joint. The bar should be three-quarters of an inch broad and extend obliquely across the whole width of the shoe immediately behind the tread (*Fig. 184*), or it may be built in between the welt and the sole where it is less unsightly but less effective. A pad of zinc oxide felt plaster can be used to protect the sesamoids from pressure when they are tender.

Operation is the only method of relieving the symptoms in the majority of patients. An arthroplasty of the metatarso-phalangeal joint is performed by one of the methods described for hallux valgus and the results in skilled hands are extremely good (Fig. 181).

also to watch for a spike at the corner of the nail; symptoms seldom recur if he is intelligent enough to do this.

OPERATION is called for when conservative measures have failed, and when the nail is very thick or is otherwise deformed. Avulsion of the nail is almost always followed by recurrence when the new nail grows and the most satisfactory procedure is to excise the nail together with the whole nail bed as for onychogryphosis (see below). Operations at which only part of the nail bed and a redundant fold of skin are removed often leave painful scars; patients likely to be cured by such operations are also likely to do well with conservative treatment.

## ONYCHOGRYPHOSIS

Hypertrophic growth of a toenail, usually of the big toe, appears to be the result of intermittent pressure continued over a long period (Fig. 189). The nail is a specialized development of the stratum corneum of the



FIG. 189 Onychogryphosis

epidermis; it is firmly adherent to the stratum mucosum, here known as the matrix, or nail bed. Growth in length takes place by proliferation of the cells of the stratum mucosum at the root of the nail, and growth in thickness by proliferation of the stratum mucosum underlying the lunula. Excessive productiveness in the latter region causes the nail to become thick, and failure to "slide" forwards properly during growth causes it to pile up and form a structure which is said to resemble a ram's horn.

**Treatment.** The nail is very hard and almost impossible to cut with scissors, but it is easily reduced by an electric burr and can be kept under control by regular attention from a chiropodist. Avulsion of the nail, although sometimes necessary for the treatment of infection, is invariably followed by recurrence.

Permanent relief can only be given by complete ablation of the nail bed. The nail is removed and a flap of skin on the dorsum of the distal phalanx is raised. All tissues down to bone are excised between a point

The temperature may be raised to between 99° and 102°. During the day there is often partial abatement of pain and approaching relief may be heralded by perspiration and mild rigors. As the attack subsides, the œdema and discolouration become less but the skin begins to itch and later desquamates. Attacks have an average duration of one to two weeks although sometimes they last longer; they almost always recur after a variable interval, but isolated attacks have been recorded.

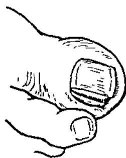
In chronic gout, tophi composed of thick, creamy fluid containing sodium biurate crystals form in the subcutaneous tissues around the affected joints, and in the bone adjacent to the articular cartilage (Fig. 187). Tophi in the lobes of the ears seldom occur in people with gouty big toes Repeated attacks lead to disorganization of the joint accompanied by symptoms resembling severe hallux rigidus, but it is unwise to perform operations similar to those for hallux rigidus and treatment should be along medical lines.

## INGROWING TOE NAIL

The principal cause of this painful condition is pressure by tight shoes or hose, or an overlapping toe, but a simple explanation cannot always be found. The deformity itself causes little discomfort; the symptoms are due to infection and therefore they often occur when the feet are ill-kept.

The nail is thickened, the curve is increased, the edges are pressed down into the soft lateral nail grooves and the surrounding skin is hypertrophied. If the free edge of the nail has not been cut across its whole width, a spike may remain hidden in the nail groove and penetrate the soft tissues as it grows. Infection is introduced by the spike, or by an ulcer that forms on the fold of skin where it is pressed against the nail, and pus spreads round the edge of the nail and penetrates between the nail and matrix. The usual signs of inflammation are present.

**Treatment.** Conservative. The first step is to get rid of the infection. The toilet of the nail is attended to, all rough edges are smoothed off, and if there is pus beneath it, part of the nail is cut away. Pledgelets of cotton wool soaked in a mild antiseptic are introduced under the free edge of the nail and into the lateral grooves.


Fig. 188

When the nail is thick and sharply curved, the direction of spring seems to be reversed causing it to curl down and press into the flesh. The traditional remedies of cutting a V into the free edge, or of shaving the centre of the dorsum thin, are based on this observation and are intended to "break the back" of the nail so that it no longer curls downwards. A groove scratched the entire length of the nail about a quarter of an inch from the margin has the same effect; this is done with the point of a knife or the corner of a safety-razor blade, the groove being deepened until the horny layer is almost perforated, that is when pain is first felt (Fig. 188). The patient is instructed to keep the groove going as the nail grows, and



Fig 191. Hammer toe with a painful corn on the dorsum of the proximal interphalangeal joint.



Fig. 193. "Spike" operation for hammer toe.

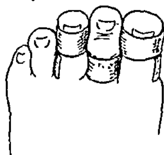


Fig 192 Method of strapping a hammer toe during infancy.

the second toe and under the third ; a second strip is placed under the tip of the second toe and passed above both the others (Fig. 192). A similar method of strapping may be used for minor valgus or varus deformities at the interphalangeal joints of any of the outer four toes.

Adults. Removal of the painful corn is nearly always followed by recurrence unless the toe is protected from pressure more or less permanently by padding. This is a troublesome business and most patients are glad enough to have the toe straightened by operation. Amputation of the second toe must never be performed because it removes the support from the big toe which then deviates outwards and presses on the third toe, then this toe curls up and requires removal also, and finally the fourth toe causes trouble.

The usual operative procedure is arthrodesis of the proximal interphalangeal joint of the affected toe. This can be done by means of a simple, transverse excision of the joint, but union is very slow. The "spike" operation is more satisfactory ; the articular cartilage is removed from the base of the proximal phalanx and a tapering hole bored in it, then the distal end of the proximal phalanx is pointed and impacted in the hole (Fig. 193). The extensor tendon may need tenotomy. After operation the toe is splinted by wrapping it with ribbon gauze soaked in mastisol. The stitches are removed on the tenth day and walking commenced ; the splint is reapplied for a further fortnight by which time union should be firm and the toe painless.

just distal to the interphalangeal joint and the centre of the nail. Particular attention is given to the lateral angles at the base of the nail bed because most troublesome spurs of nail continue to grow if any matrix is left. The distal portion of the phalanx is excised to shorten the toe and provide enough skin to cover the raw area.

## SUBUNGUAL EXOSTOSIS

A small exostosis sometimes grows on the dorsum of the distal part of the terminal phalanx, most frequently of the big toe (Fig. 190). As it gets larger it lifts up the nail matrix and compresses it against the nail; ultimately the matrix degenerates and forms a horny scab over the exostosis.



FIG 190 Subungual exostosis

The condition is very painful and can only be relieved by operation. If dealt with early, the exostosis can be approached through a lateral incision and the matrix dissected up without being perforated; healing is then by first intention and convalescence is short. If, however, the matrix has ulcerated, a raw area is left after removal of the exostosis and it has to heal by granulation.

## HAMMER TOE

A hammer toe (Fig. 191) has a right angle flexion deformity at the proximal interphalangeal joint; the soft tissues underneath are contracted and prevent the toe being straightened. The distal interphalangeal joint may be flexed, straight or hyperextended. The metatarso-phalangeal joint is hyperextended and the proximal phalanx rests on the dorsum of the metatarsal head pointing obliquely upwards; the extensor tendon is contracted and stands out over the joint.

The deformity may be present in only one toe, most frequently the second, and less often the third or fourth. It may be symmetrically bilateral, and sometimes several toes are affected. The cause is uncertain, but in a few instances there is familial history; in some patients the toe is drawn up as if to avoid pressure from a deformity of the next toe, usually a valgus big toe, and sometimes, when the toe is unduly long, ill-fitting shoes or hose may be responsible.

Many hammer toes are symptomless, but some are most painful. Pain may be due to a corn on the dorsum of the contracted joint or on the extreme tip of the toe, or it may be due to metatarsalgia caused by the toe forcing the metatarsal head downwards and making it prominent in the sole of the foot.

**Treatment.** BABIES. The toe can be held straight by strapping it to its neighbours but this has to be continued for many months, possibly years, to obtain a permanent result. A narrow strip of adhesive plaster is wound round the base of the toes starting under the big toe, passing above



FIG 194. Mallet toe. There is a painful corn on the tip close to the nail

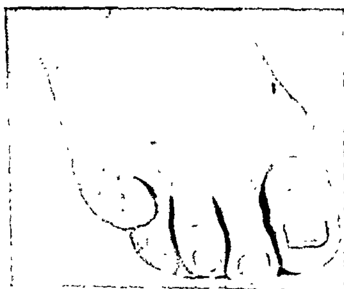


FIG. 195 Dorsal displacement of the fifth toe.



FIG 196 Dorsal exostoses at the first tarso-metatarsal joints.

## MALLET TOE

A mallet toe is one with a flexion deformity at the distal interphalangeal joint and it may occur at any of the outer four toes (Fig. 194). The condition may be painless, or there may be pain from a corn on the dorsum of the joint, or on the tip of the toe close to the nail. The latter is particularly painful and resistant to conservative treatment.

**Treatment.** In children the deformity may be prevented from becoming fixed by strapping in a similar way to hammer toe. Adults can be kept comfortable as long as they are prepared to visit the chiropodist regularly to have the corn attended to and the toe padded.

*Operation is usually preferred. A "spike" operation as for hammer* toe is impracticable because of the small size of the distal phalanx. Simple excision of the joint has therefore to be performed, but union is usually by fibrous tissue and it may be some time before there is complete freedom from pain. A more rapid result is obtained by amputation of the terminal phalanx.

## DORSAL DISPLACEMENT OF LITTLE TOE

This is a congenital deformity in which the little toe is displaced dorsally and twisted so that it lies across the base of the fourth toe (Fig. 195); with an extreme deformity, the toe is angulated 90° and lies on the neck of the fourth metatarsal. The defect is rather unsightly, and makes it difficult to find a comfortably fitting shoe, but apart from this it does not cause much trouble in children. In adults, however, there is often pain due to pressure and friction, and a painful soft corn that will not yield to conservative treatment forms between the toes.

Replacement of the toe in its proper place during childhood is followed by a return of function, but if it is replaced during adult life, the toe remains functionless although the cosmetic result is good. Reposition is, therefore, *best performed during childhood, preferably about eight to ten years of* age. The extensor tendon is divided and the dorsal capsule of the metatarsophalangeal joint incised; the toe then falls into position but the skin is stretched so tightly that it requires "lengthening" by the V-Y or a similar method.

## DORSAL EXOSTOSIS

A rather troublesome prominence often develops on the dorsum of the foot in connection with the first tarso-metatarsal joint (Fig. 196). It is not a true exostosis but an enlargement of the first metatarsal and first cuneiform bones on each side of the joint. Sometimes an adventitious bursa forms over it.

The swelling is just where the strap of a certain type of shoe crosses the foot. Symptoms may be caused by friction or pressure, and they are usually relieved by a change of footwear. If necessary, the prominence can be removed surgically; a saucer-shaped depression should be cut in the bone or some swelling will remain after operation.

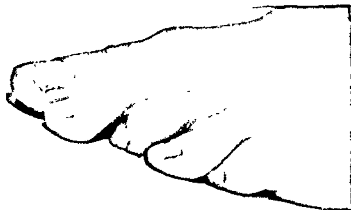


Fig 194 Mallet toe There is a painful corn on the tip close to the nail



Fig 195 Dorsal displacement of the fifth toe



Fig 196 Dorsal exostoses at the first tarso-metatarsal joints

## PLANTAR WARTS

Plantar warts (*verruca pedis*) are very common, especially in young people, and exceedingly painful. They may occur anywhere on the sole of the foot but usually under the heel, the ball, or the terminal phalanx of the big toe. They vary in size from minute seeds up to an inch in diameter.

There is doubt about the ætiology but the evidence is in favour of an infective origin, the causative organism possibly being a filter-passing virus. Local dissemination takes place around the primary wart and there may be a whole crop close together. Warts are transferred from person to person by direct contact, and through intermediate agents such as socks and bath mats; epidemics in schools are therefore common.

A wart has a typical papillomatous structure, but instead of projecting beyond the skin it is buried under the horny layer with only the tips of the papillæ sticking through. It appears as a circular area with a dark, punctate surface and is excruciatingly tender to touch. It may be necessary to shave off the superficial layer before the typical appearance can be recognized.

**Treatment.** Small warts can usually be destroyed by a caustic, almost any caustic will do. Glacial acetic acid is easy to handle and may be re-applied every two or three days; the horny layer should be pared down before application. The actual cautery, carbon dioxide snow and electrolysis are also used with success.

Larger warts are difficult to destroy completely by local applications but they are readily removed with a sharp curette. The margins extend some distance under the skin and it is essential that no fragments are left behind; it is advisable to use a tourniquet to prevent the view being obscured by blood. The resulting hole is plugged with cotton wool; it is sometimes of alarming size but it fills up rapidly and heals without leaving a scar. It is seldom necessary to keep the patient in bed.

*Radiotherapy may be the method of choice for large warts or multiple* smaller ones. No change occurs for about a week and then the surrounding skin becomes slightly red and tender; after six to eight weeks the horny layer separates leaving normal skin beneath.

## PERFORATING ULCER

All the ordinary forms of ulcer occur on the foot and follow the usual clinical course, but perhaps they are more indolent than elsewhere. Perforating ulcers are not peculiar to the foot although they are rare elsewhere. They are usually found under the first metatarsal head, less often under the fourth and fifth metatarsal heads, and occasionally at any other weight-bearing site including the interphalangeal joint of the big toe.

"Ulcer" is a misnomer because ulceration is the least obvious feature; there is a sinus with a small opening concealed in a mass of heaped-up callous (Fig. 197), and the sinus leads to a cavity deep in the foot which may ramify between the metatarsals and extend to the subcutaneous tissues at the dorsum. There may be a low-grade osteomyelitis of the metatarsal



Fig 197 Perforating ulcer in a patient with tabes dorsalis



bones. The absence of pain is characteristic and most sinuses can be probed, and sometimes even curetted, without causing pain.

Perforating ulcers are found in association with diseases in which there is interference with the sensory nerves and the blood supply of the foot. The commoner of these are diabetes, peripheral nerve injuries, tabes dorsalis, syringomyelia and peripheral neuritis. The vascular element is most conspicuous when the sympathetic nervous system is disordered.

**Treatment.** The systemic disease should first be treated, and when this is tabes, antisyphilitic measures will probably improve the local condition. Rest is essential in the presence of active pyogenic infection. Drainage is provided by removing the callous around the sinus, taking care not to damage the healthy skin, and then enlarging the opening. The sinus is irrigated with a mild antiseptic and lightly packed to keep it open. The cavity closes from the bottom very slowly and, although it seldom heals completely, it should be possible to keep it in control for an indefinite period. Radical surgery is not advisable, but if the dorsum of the foot is swollen, it may be necessary to incise it and remove necrotic bone; the incision should be dorsal. Lumbar sympathectomy requires consideration when there is evidence of vasospasm.

## CORNS AND CALLOUS

Corns and callous are both produced by intermittent pressure and friction over an area of solid resistance. There is no satisfactory explanation as to why some corns develop in such a way as to be painful, and some do not. *Painful corns are important not only because of the attendant pain,* but also because they cause mis-use of the foot which leads to other troubles like metatarsalgia.

Corns may be hard or soft and there is no essential difference between them.

HARD CORNS. These form over bony prominences, particularly at the outer side of the little toe, over the dorsum of an interphalangeal joint, and under the tip of the toe close to the nail. They are composed of an area of hyperkeratosis with a more deeply penetrating central nucleus which also is keratinous, but partly degenerated. The pain is due to pressure on the nerve endings in the papillary layer of the dermis. There is often a small sac containing fluid underneath the nucleus, and periodic exacerbations of pain may be due to recurrent inflammation of the sac.

SOFT CORNS. They favour moist places where skin is in contact with skin, *the commonest site being between the fourth and fifth toes.* They have a soft, whitish appearance with a depressed central area, but in structure are essentially the same as hard corns.

CALLOUS. Most people have some callous around the heel and under the ball of the foot, but the amount varies with the individual and it is difficult to say when it becomes pathological. *Callous normally is painless*; it becomes painful because of changes in the deeper layers resembling those in a corn. The severity of pain depends on these changes and not on the thickness of the callous.

**Treatment.** A corn can almost always be cured by local treatment but it will certainly recur unless the cause is removed. The cause may be found in badly-fitting shoes, deformities of the toes or foot, or faulty use of the foot.

Local treatment of a corn is described by chiropodists as being "non-operative" and "operative." Non-operative methods rely on softening the keratinized skin by repeated applications of a preparation containing salicylic acid, or some similar agent ; the horny layer eventually separates and often carries the central nucleus with it. Operative treatment is most skilfully performed by the chiropodist ; the hardened layer is either dissected away from the healthy skin or pared down until level with it, and the nucleus is removed intact. Surgical excision of a corn is very seldom needed.

Painful callous can be got rid of by the same methods as corns, but it is very difficult to prevent it recurring and relief usually lasts only too short a time. The worst growths cannot be controlled by chiropody and it may be necessary to excise the skin of the affected area and replace it with a graft. Radiotherapy is sometimes advised but it must be carried out with extreme caution because of the risk of burning the sole of the foot.

## RINGWORM

Mycelial infection between the toes is exceedingly common even in temperate climates, and in hot climates it is almost universal. The infection starts as a rule in the cleft between the fourth and fifth toes and rapidly spreads to the others. If kept dry, the skin cracks and desquamates leaving sore patches, but when moist, it becomes white and sodden. The condition is not really troublesome unless there is secondary infection and then the usual signs of acute inflammation are present, sometimes including cellulitis of the toes and dorsum of the foot. The diagnosis depends on demonstration of the fungus, but intertrigo of the toes from other causes is uncommon and microscopic examination is unnecessary as a routine.

**Treatment.** The infection is not difficult to control, or even to cure. The problem is to prevent re-infection and this is next to impossible in the ordinary conditions of community life. Meticulous attention to the hygiene of the feet is the most important practical measure; they should be washed and properly dried twice daily, and the socks as frequently. The toes should be kept as dry as possible by the liberal use of powder. The acute stages need antiseptic treatment; sodden skin is carefully removed and then the toes are soaked in a solution of potassium permanganate, brilliant green, methyl violet or other colour according to taste. Innumerable remedies and formulæ have been advocated, and although most are successful at first, none prevent re-infection.

## HYPERIDROSIS

Excessive sweating of the feet may be a local phenomenon or a symptom of a generalized condition. Sweating is under the control of the sympathetic nervous system and no satisfactory explanation has been offered as to why excessive sweating often occurs in the feet alone. When severe, the sweat pours off the feet, the skin becomes sodden, the socks need changing many times daily, and both socks and shoes rot quickly. In some cases the sweat decomposes and has an offensive smell.

**Treatment.** Minor degrees can usually be kept in control by careful attention to the toilet. The feet should be washed frequently in a mild deodorant and dried with spirit, and the feet, socks and shoes dusted liberally with a powder composed of equal quantities of talcum and boracic acid. Severe degrees may be helped by regular application of X-rays at carefully spaced intervals; occasionally lumbar sympathectomy, which prevents all sweating in the limbs, is justified.

## PAIN UNDER THE HEEL

This common complaint is nearly always due to the same cause—inflammation of the plantar fascia and the short muscles at their attachment to the calcaneus (*plantar fasciitis*). Pain and tenderness are accurately localized to a small area beneath the heel, usually on the inner side immediately in front of the pad. It is felt chiefly on standing or walking, and is relieved by rest.

The inflammation may be traumatic or infective in origin. Associated focal sepsis is common and perhaps has a better claim to be accepted as causative than in many other conditions attributed to it. Sometimes the condition follows influenza and sometimes gonorrhœa, but with the latter there is usually a more widespread plantar fasciitis causing tenderness all over the sole.

The relationship of spurs of the calcaneus to pain under the heel is often misunderstood. Spurs are produced by ossification in the plantar fascia and the tendinous origin of the muscles as the result of inflammation or repeated minor trauma (Fig. 198). They are often seen in radiographs taken for other reasons, and are often present in both feet when there is



*Fig* 198. A calcaneal spur is seldom a cause of pain

pain in only one. Spurs do not cause pain unless they are very large; the pain in plantar fasciitis is identical whether a spur is present or not, and in both cases the pain is due to inflammation.

**Treatment.** The teeth and tonsils should first be examined and any definite infection attended to because the response to elimination of sepsis is occasionally dramatic. Many cases, however, are very resistant to treatment and may take months to clear up. Pain can be relieved temporarily by an injection of proctocain, and if repeated several times the result is sometimes permanent. Comfort is given by a sorbo pad cut to fit the heel of the shoe and hollowed out exactly opposite the tender area. Diathermy may assist resolution, but usually it has to be continued for a long time.

Surgical excision of spurs is disappointing because spurs do not cause pain unless they are large enough to be palpable in the sole. Excision of the plantar fascia and muscles for a distance of about half an inch from their attachment to the calcaneus, together with a spur if one happens to be present, is sometimes successful and may be tried when all other treatment has failed.

## PAIN BEHIND THE HEEL

Pain behind the heel may originate in any of the structures composing the heel, viz., the skin, the subcutaneous tissues, the tendo-Achillis, the retro-tendinous bursa, the calcaneus and its apophysis (Fig. 199).

### Skin and Subcutaneous Tissues

Inflammation behind the heels is common in girls and young women, but it is less often seen in boys. The skin is red, swollen and tender as if with a chilblain, the subcutaneous tissues are thickened and a bursa may form superficial to the insertion of the tendo-Achillis. The symptoms are worse in cold weather and are said to be more common since silk stockings came within the capacity of every purse.

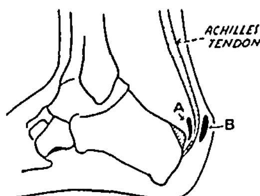



FIG 199 A Retro-tendinous bursa B Subcutaneous bursa The shaded area of the calcaneus, when enlarged, may require removal

Often the cause of the trouble cannot be found, but sometimes it appears to be due to friction between the heel and the top of the back of the shoe; the latter is often made to curve inwards more sharply than it need in an attempt to get a snug fit. Sometimes the cause is enlargement of the postero-superior angle of the calcaneus which projects backwards making a lump under the skin; and sometimes the lateral, vertical borders of the calcaneus are enlarged but then the pain and swelling are situated lower and more laterally.

**Treatment.** The condition is seldom seen after about twenty-five years of age, and therefore there must be a strong tendency to spontaneous recovery. Mild pain can be relieved by attention to the fitting of the shoes, and by wearing a "heel protector" obtainable from most shoe-shops. When there is enlargement of the posterior angle of the os calcis, high heels tilt the bone forwards and help to relieve pressure, but if there is no enlargement, low heels are more suitable.

Operation may be necessary to remove a subcutaneous bursa or an enlargement of the calcaneus; the postero-superior angle of the latter is bevelled off with a chisel down to the level of the insertion of the tendo-Achillis (Fig. 199). A lateral incision must be used to prevent friction on the scar.

### Tenosynovitis

Tenosynovitis of the tendo-Achillis sheath occurs as the result of "over-use" in athletes, ballet dancers, etc., and is recognized by palpable creaking on active movement. It responds well to rest. The foot is strapped in extreme plantar flexion; three strips of half inch adhesive plaster are fixed along the whole length of the sole, round the back of the heel, up the calf as far as the knee, and secured with a few circular bands (Fig. 201). It is then possible to walk wearing a shoe with a raised heel but patients should be warned not to stand, even for a moment, without them. Diathermy is a useful adjuvant.

The bursa between the tendo-Achillis and the calcaneus, and also the fibro-fatty tissues between the tendo-Achillis and the tibia, occasionally become inflamed. The response to rest is usually good but sometimes excision is necessary.

### Apophysitis of the Calcaneus

(*Synonym*) Haglund's Disease

This condition occurs in children of eight to fourteen years of age and is probably a form of osteochondritis juvenilis (p. 140). The symptoms are pain, swelling and tenderness at the back of the heel. The X-rays show sclerosis and fragmentation of the apophysis and sometimes areas of rarefaction in the adjoining metaphysis (Fig. 200).

The condition runs a benign course and usually recovers in a few months. It is not necessary to keep the child in bed, but games and drill should be avoided. Pressure on the heel, if painful, can be prevented by removing the stiffening from the back of the shoe or cutting a hole in it; thin-soled shoes or plimsols should not be worn.

## RUPTURE OF THE TENDO-ACHILLIS

This is an injury of middle-aged men and less often of other people. The classical occasion for it to happen is when father turns out to play in *Parents* v. *Boys* at cricket; on starting to run he gets a sudden pain behind the ankle as if from a blow, and he falls over. The rupture is usually about one and a half inches above the insertion of the tendon where it is narrowest, and it may be complete or partial

**Complete Rupture.** The upper end of the tendon retracts and at first a gap is palpable, but it quickly fills with blood clot and then there is a small firm lump instead of a hollow. The gap in the tendon can be demonstrated radiologically.

Conservative Treatment consists in raising the heel of the shoe and strapping the foot in equinus (Fig. 201), or applying a plaster cast with the foot in the same position. The position should be maintained for six to eight weeks by which time fibrous tissue will have grown across the gap and united the ends of the tendon. The function is reasonably good but the tendon remains rather longer than before, the gait loses some of its spring, and the power of standing on tiptoe may be permanently lost.



*Above* FIG. 200 Apophysitis of the calcaneus



*Right* FIG. 201 Strapping the foot in equinus

OPERATION is usually preferable. If the injury is recent, end to end suture may be possible, but the tendon is often in a friable condition and it is difficult to obtain a firm hold for the sutures. With old injuries and some recent ones it is necessary to fashion a flap from the proximal end of the tendon, and if possible from the distal end also, and suture them together (the tendon of the plantaris muscle, if present, makes a good living suture). A walking plaster is applied with the foot at right angles to the leg and worn for two months.

**Partial Rupture.** A number of the fibres of the tendon are torn; no gap is palpable, but after a short time a lump forms, as with complete rupture. Continuity of the tendon can be demonstrated radiologically. The foot should be strapped in equinus for several weeks and there is complete restoration of function within a few months.

## "PULLED CALF MUSCLE"

This requires separate mention because sudden pain in the calf whilst engaged in sport, and on similar occasions, is commonly ascribed to rupture of the tendon of the plantaris muscle. The plantaris tendon is long and slender, and knowing that the powerful tendo-Achillis can rupture, it is tempting to assume that the plantaris may behave in the same way. As far as I am aware, however, a ruptured plantaris has never been observed at operation. Sudden pain in the calf is due to rupture of a few fibres of the triceps suræ, an injury which is identical with "pulled" muscle occurring in the thigh and requiring similar treatment (p. 183).

## THE LATERAL LIGAMENTS OF THE ANKLE

The lateral ligaments of the ankle are injured when the foot is forced violently into inversion or eversion, usually inversion. The ankle depends for its lateral stability on the muscles of the calf which have long tendons passing behind the malleoli, but these muscles are primarily concerned with the posture of the foot and control of the ankle is only a secondary function. It often happens, therefore, that the ankle is subjected to violence when the muscles are not prepared to receive it and then the strain is taken by the ligaments. The accident usually occurs whilst walking or running on



Fig 202 Manipulation of ankle—dorsiflexion

rough ground when the foot twists and the whole weight of the body comes onto the lateral ligament. The resulting damage may consist of a minor sprain, or a large part of the ligament may be ruptured. In either case there are likely to be troublesome chronic symptoms unless proper treatment is given.

### Sprain

A sprain is an injury in which a number of the fibres of a ligament are torn. The usual sites to be affected at the ankle are the lower insertions of the anterior and middle fasiculi of the external lateral ligament, and the upper insertion of the ligament into the external malleolus. Sometimes the anterior capsule of the ankle, usually the outer part, is damaged at its insertion into the tibia, and sometimes the internal lateral ligament is injured at either its upper or lower insertion.

A sprained ankle swells rapidly, there may be œdema of the foot, and also subcutaneous bruising if the injury is severe. There is tenderness at the site of injury, and pain is caused by stretching the ligament. Fracture can usually be excluded by localizing accurately the site of pain and tenderness.

Treatment. The sooner treatment is commenced, the more likely is resolution to take place quickly and completely. Rest is contra-indicated

except after severe injuries. When possible the ankle should be bound with elastoplast immediately after injury and before there is any swelling; if some hours have elapsed since the injury, it is helpful to infiltrate the tender area with novocain before the elastoplast is applied. The strapping should extend from knee to toes and an additional turn is made around the ankle to give lateral support. The patient is then taught to walk without a limp in order to ensure proper movement of the ankle. He should lead as normal a life as possible avoiding only games and competitive sport, and he should continue training if engaged in athletics. The elastoplast requires renewal after a week, or earlier if there has been much swelling, and it can usually



FIG 203 Manipulation of ankle—stretching the middle fasiculi of the external lateral ligament

be discarded after a fortnight. Massage, and possibly further infiltration with novocain, are desirable if pain persists.

**Chronic Sprain.** When an acute sprain is inadequately treated a painful scar often forms in the ligament. In a severe case there is pain whenever the ligament is placed under strain, as when walking on rough ground, and there may be recurrent attacks of swelling following minor twists of the ankle.

TREATMENT is by manipulation under anæsthesia. The anterior fasiculi of the external lateral ligament are placed under tension by forcing the foot into full inversion and plantar flexion, the middle fasiculi are stretched by the method shown in Fig. 203, dorsiflexion is restored as in Fig. 202, and the ankle is distracted as in Fig. 161, p. 214. After manipulation the range of movements should be maintained by massage, passive movements and active exercises.

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or wearing shoes with *Louis* heels. The diagnosis, as with the acute lesion, is made radiographically, and an anaesthetic may be necessary before the defect can be demonstrated.

**Treatment.** The only satisfactory method of treatment is by operation. Several techniques have been described, the best being *Watson-Jones's tenodesis* (Fig. 205). The upper end of the tendon of the peroneus brevis is detached from the muscle belly, passed from behind forwards through a drill hole in the external malleolus, then from above downwards through the neck of the talus, and finally implanted into the external

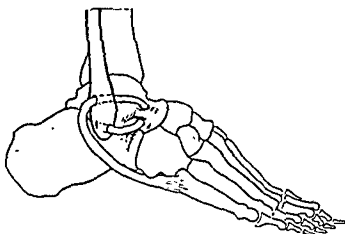


FIG 205 Watson-Jones's tenodesis for recurrent subluxation of the talus

malleolus. The foot is immobilized in a plaster cast for eight weeks but weight-bearing is permitted after a fortnight. A long period of physiotherapy is necessary after the plaster has been removed, and the end-result is good.

## Giving Way of the Ankle

This common complaint troubles women more than men. The ankle gives way as a rule into inversion, and only occasionally into eversion. It usually happens when walking on rough ground although it may occur when on a level surface. The ankle twists very suddenly and often the lateral ligament is sprained producing the usual symptoms of pain and swelling.

Frequently there is a definite cause for the ankle giving way but sometimes no explanation can be found. The known causes are chronic sprain of the external lateral ligament, and recurrent subluxation of the talus. The treatment of both these conditions is described above. When no cause can be found it is tempting to attribute the trouble to high heels, or to wearing shoes with unevenly worn heels which do not rest flat on the ground. But although the ankle gives way less often when wearing good shoes and low heels, it still happens occasionally for no discoverable reason, even when walking on the level. Recurrent dislocation of the peroneal tendons causes comparable symptoms and may be mistaken for "giving way of the ankle."

## Rupture of External Lateral Ligament

Complete rupture of the ligament is a not uncommon injury which is caused by the same sort of accident as a sprain. The ligament usually gives way close to its insertion into the fibula and part of the anterior capsule of the ankle is torn at the same time. Sometimes the ligament remains intact and a flake of bone is avulsed from the tip of the fibula.

The injury is serious because it enables the talus to tilt in the mortice of the ankle making the joint most insecure. It should be suspected when



FIG. 204 Complete rupture of the external lateral ligament permits subluxation of the talus

there is a severe sprain followed by considerable swelling and bruising, and the tenderness is localized to the upper insertion of the ligament. Sometimes unnatural mobility of the ankle can be demonstrated on examination, but often clinical diagnosis is uncertain ; when there is doubt, an X-ray should be taken whilst the foot is forced into inversion, preferably with the patient anæsthetized (Fig. 204).

TREATMENT. The condition must be treated seriously or the ankle will remain permanently weak. The joint is immobilized in a walking plaster extending from the knee to the toes for a period of eight to ten weeks ; the foot should be at right angles to the leg and in a plantigrade position, neither everted nor inverted. A prolonged course of physiotherapy is necessary afterwards to restore the full range of painless movements.

## Recurrent Subluxation of the Talus

Untreated rupture of the external lateral ligament leaves an unstable ankle in which the talus can be tilted laterally some 60° (Fig. 204). The ankle continually "gives way," particularly when walking on rough ground,

there are often two, and under the inter-phalangeal of the big toe, where there may be one. There is occasionally a single one at the second and fourth metatarso-phalangeal joints, the second and third proximal inter-phalangeal joints and the terminal interphalangeal joint of the third toe (Fig. 206).

## Accessory Bones

A number of small bones are found in the foot from time to time in addition to the usual bones of the tarsus. Their importance to the surgeon lies in the ease with which they may be mistaken in radiographs for fractured normal bones. The incidence varies from about 8 per cent in the case of the os trigonum, to rareties like bipartite first cuneiform. They are often, but not always, bilateral.

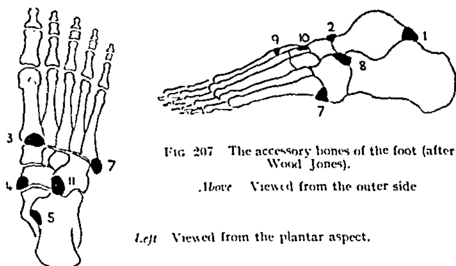



FIG. 207 The accessory bones of the foot (after Wood Jones).

*Above* Viewed from the outer side

*Left* Viewed from the plantar aspect.

Wood Jones emphasizes that accessory bones are not atavistic remnants of a former wider series of tarsal bones, as is often suggested in textbooks of anatomy. He states that only one bone of the primitive vertebrate tarsus is lacking as a separate element in the human foot, the os intermedium. This bone has been absorbed into the talus, but it often fails to fuse with the body of the talus and then it is known as the os trigonum. The remainder of the accessory bones must be considered as congenital anomalies in ossification. The following list is not exhaustive.

1. Os trigonum.
2. Dorsal talo-navicular ossicle.
3. Pars peronea metatarsalis primi.
4. Os tibiale externum (naviculare secundarium).
5. Os sustentaculi.
6. Os cuneiforme primum bipartum.
7. Os Vesalii.
8. Os calcaneus secundarius.
9. Os intermetatarsum.
10. Os intercuneiforme et os paracuneiforme.
11. Cuboides secundarius.

## DISLOCATION OF THE PERONEAL TENDONS

The peroneal tendons lie in a groove as they curve round the external *malleolus. They are held in position by the fibres of the lower part of the* anterior annular ligament which pass in front of them to be inserted into the calcaneus. Dislocation of the tendons onto the outer surface of the malleolus occurs when the retaining ligament has been ruptured, and also without violence when the groove is shallow and the ligament lax. It happens when the ankle is dorsiflexed and is readily reduced by plantar flexion. The patient may not be aware of what has happened and the history is not unlike that when the ankle "gives way."

**Treatment.** When dislocation is due to injury and the correct diagnosis is made at once, a pad of felt is placed over the tendons behind and below the malleolus and the ankle is strapped with elastoplast. The strapping requires renewal at intervals for six to eight weeks by which time the ligament is usually found to be healed.

Recurrent dislocation can only be relieved by operation. There is sometimes sufficient ligamentous tissue available to reconstruct the torn ligament, and when this can be done it gives a good result. When the groove for the tendons is shallow, *Watson-Jones's operation* is indicated; a thick osteo-periosteal flap is raised from the outer surface of the external malleolus and rotated so that part of it lies in front of the tendons and forms a tunnel for them.

## ACCESSORY AND SESAMOID BONES

### Sesamoid Bones

Sesamoid bones occur in tendons at situations where they are under pressure, or where they curve round smooth, bony prominences. They begin as thickenings in the tendons, later they are converted into cartilaginous nodules, and finally some, but not all, ossify. Ossification usually commences during childhood although it may take place at any age, even in elderly people.

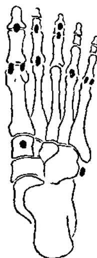


Fig. 206 The sesamoid bones (after Wood-Jones)

Sesamoids are of surgical importance because they can be mistaken for *loose bodies in joints, and occasionally for a* fractured bone. The two sesamoids under the first metatarsal head are the only ones in the foot that are constantly present and have a clearly defined function; the inner of these may be in two parts, and occasionally in three or four parts (Fig. 173, p. 226).

*An ossified sesamoid is found with some frequency* in the peroneus longus where it curls round the cuboid. Another occurs, but less often, in the tendon of the tibialis posterior deep to the navicular bone. Others may be found in the tendons of the short flexors of the toes beneath the metatarso-phalangeal joints, and in the long flexors beneath the inter-phalangeal joints. The commonest sites are *under the metatarso-phalangeal joint of the little toe* where





*Above:* Fig 208 Tuberculous disease of the first metatarsal.

*Left:* Fig 209 Tuberculous disease of the ankle. The primary focus is at the inner side of the astragalus. Note the rarefaction of the lower end of the tibia with a well defined upper limit.

depressed slightly lower than the fifth to enable it to take the weight when walking.

Fixation may be by means of a metal splint or a plaster-of-Paris cast. A metal splint leaves the foot and ankle exposed for inspection so that abscesses can be detected early and sinuses treated if necessary. Plaster casts should be bivalved for the same purpose. Weight-bearing is permitted when recalcification is well advanced, but protection by a walking plaster or a walking iron is necessary for a further period.

**Operative.** Excision of a single infected bone is very occasionally possible when an early diagnosis has been made. After the disease has spread outside the confines of the bone, the attempt to eradicate it seldom succeeds and the final functional result is then worse than if there had been no surgical intervention. Excision of the talus sometimes appears very attractive, but only too often radiographs fail to reveal the full extent of the infection.

Amputation is the only sure method of getting rid of the local infection. It is seldom necessary in children because the prognosis as regards both healing and subsequent function are good. In adults, the position is different. Conservative treatment does not always control the disease, and it is very irksome to an otherwise fit patient; moreover, the disability following amputation is often less than if the disease is allowed to run its course. Unless resistance to the infection is quickly shown to be exceptionally good (there should always be an initial period of observation and general treatment) early amputation may be accepted as a welcome relief.

## TUBERCULOSIS

Any of the bones or joints of the foot and ankle may be affected by tuberculosis. The initial focus is more often in bone than in synovial membrane although usually the latter is involved after a short time. The bones most commonly affected are the talus, calcaneus, lower end of tibia, navicular and cuboid in that order of frequency. These bones form the ankle, subtaloid and mid-tarsal joints which therefore are the usual joints to be involved. Of the remaining bones, only the first metatarsal is infected with any frequency (Fig. 208). The maximum incidence is from two to seven years, but no age is immune.

The clinical picture is of slowly progressive swelling, stiffness and pain. Pain is not a marked feature and often tenderness is significantly absent in the early stages. Swelling and stiffness are frequently the first complaints.

Infection of the talus usually commences in the juxta-articular bone adjoining the ankle or talo-navicular joints, and later the corresponding joint is involved. When the ankle is infected there is swelling on each side of the tendo-Achillis and in front of the joint; the foot is held by spasm in equinus and attempts to force movement are painful. Disease of the other tarsal bones causes local swelling, and spasm of the muscles controlling the neighbouring joints.

The disease follows the usual course of bone and joint tuberculosis but, in the absence of early treatment, spread to neighbouring bones readily takes place and the whole tarsus may be disorganized. Abscesses are necessarily superficial because of the paucity of soft tissue covering; even when they are detected early the aspirating needle cannot always be directed along a "valvular" track and it is difficult to prevent sinuses.

The X-rays show the usual appearance of a tuberculous bone (Fig. 209). The first sign is a localized area of trabecular absorption followed, after involvement of a joint, by irregularity in the outline of the joint and narrowing of the joint space. Generalized decalcification is often severe and may involve most of the tarsus and the lower few inches of the tibia.

### Treatment

**Conservative.** Conservative treatment when carried out in proper conditions gives satisfactory results and in children the prognosis is good. But because of the ease with which the foot can be immobilized in plaster whilst the patient goes about on crutches, and because of the scarcity of special hospital accommodation, there is a temptation to forget the importance of general treatment.

Local treatment consists in prolonged immobilization. The posture of the foot must be arranged with meticulous care or it may become ankylosed in a position unsuitable for weight-bearing and cause endless trouble. The optimum position provides half an inch of equinus for boys, and somewhat more for girls to allow for the heel of the shoe; the forefoot must be correctly aligned with the ankle and knee, and the first metatarsal

# TALIPES

(*Synonym*) Club-foot

The word talipes is derived from the latin *talus* and *pes*, and originally was applied only to those who "walked on the ankles." Later it was extended to include all deformities of the feet, but the modern tendency is to restrict its use to congenital deformities. Acquired deformities are more usually preceded by the word *pes*, e.g. pes cavus, pes valgus, pes equinus.

Talipes are subdivided into four varieties :—

| | |
|---|---|
| *Talipes Equinus.* | Plantar flexion of ankle and foot. |
| *Talipes Calcaneus.* | Dorsiflexion of ankle and foot. |
| *Talipes Varus.* | Inversion and adduction of the foot. |
| *Talipes Valgus.* | Eversion and abduction of the foot. |

These deformities do not usually occur alone, but in combination. The incidence is given by Whitman as .—

| | |
|---|---|
| Talipes Equinovarus .. .. .. .. | 77 per cent |
| Talipes Valgus .. .. .. .. .. | 7 per cent |
| Talipes Varus .. .. .. .. .. | 4 per cent |
| Talipes Calcaneo-Valgus .. .. .. | 4 per cent |
| Talipes Equinus .. .. .. .. .. | 2 per cent |
| Talipes Calcaneus .. .. .. .. | 2 per cent |

The condition is bilateral in nearly half the cases, and when unilateral the right foot is affected slightly more often than the left. It is not uncommon for the deformity to be different on the two sides, as might be expected if a mechanical view of the ætiology is accepted.

## Ætiology

The cause of congenital talipes has been the subject of speculation for centuries but, of the many theories advanced, only the ancient view of Hippocrates and Galen has remained unshaken. It has recently been elaborated with convincing argument by Denis Browne. According to this theory talipes is of mechanical origin and belongs to a group of "moulding" defects which includes dimples, lumbar spina-bifida, acro-cephalo-syndactyly and other deformities of the hands. All this group is said to be caused by abnormal intra-uterine positions of the fœtus, with sometimes the additional factor of increased mechanical or hydrostatic pressure. Dimples normally form at certain sites like the point of the elbow, and they are also common over the convexity of deformities ; they may be due to pressure between the uterine wall and a bony projection which causes an adherent subcutaneous scar to form. Heredity appears to be a factor in a few instances because the deformity is occasionally familial.

The normal intra-uterine position is such that the feet are dorsiflexed and the soles are in contact with the wall of the uterus—the foot of a new-born baby can be dorsi-flexed until the big toe touches the shin. There are several positions causing abnormal moulding of the feet. The commoner are those in which the *outer border or heel* of one foot is pressed

## SWELLING OF THE FOOT AND ANKLE

Swelling of the foot and ankle may be caused by (1) œdema, (2) hypertrophy of the subcutaneous fat, and (3) tumours and diseases of the deeper structures. Systemic disease must always be excluded before œdema is attributed to a local cause.

**Œdema.** Injury to the foot, whether a fracture, an acute sprain or chronic foot strain, is almost always accompanied by œdema. The swelling increases during the day and its lower limit is sharply defined by the shape of the shoe; it diminishes or disappears at night when the limb is elevated. It is very persistent because there is no large bulk of muscle to assist in removing it mechanically. Continued œdema is an indication that an injury has not completely resolved; this is particularly noticeable with an acute sprain that has become chronic, and in a foot that has become stiff after immobilization in plaster for, say, fracture of the tibia. The swelling does not go completely until the full range of painless movements has been restored.

Œdema of the foot and ankle frequently follows injury of higher parts of the limb because the excess of tissue fluid gravitates downwards. It may also be caused by lymphatic or venous obstruction at the groin and pelvis. Occasionally œdema of lymphatic type with cellular hypertrophy in the subcutaneous tissues occurs without any discoverable cause and then an operation of the Kondoleon type may give partial relief.

There is a type of œdema occurring chiefly in young women of eighteen to twenty-five years of age which is not associated with trauma or visceral disease. It may be unilateral or bilateral and it is painless, complaint being made only of the appearance. Osmond has shown that this type may be due to a disorder of water metabolism and is associated with a low alkali reserve. It can often be relieved by the administration of massive doses of alkali. Sodium citrate is given commencing with 600 grains daily divided into nine or ten two-hourly doses, each taken in glass of water. The daily quantity is increased every fourth day by 200 grains up to a maximum, which is determined by the onset of gastro-intestinal symptoms, of about 1,200 grains, and this is continued for a week.

**Hypertrophy of the Subcutaneous Fat.** The subcutaneous fat sometimes hypertrophies to such an extent that it hangs in folds round the ankles. This occurs chiefly in those who are already overweight because of some metabolic disturbance. Excision may be attempted for cosmetic reasons but it is not very satisfactory unless the primary disorder can be relieved.

**Diseases and Tumours** of every sort affecting bones, joints or tendons are liable to cause swelling. Difficulty has often been occasioned by a diffuse synovioma which frequently is wrongly diagnosed before operation, much to the surprise of the surgeon who thinks he is only going to encounter a lipoma. Complete excision of this tumour is essential to prevent local recurrence and a very extensive dissection following the tendons into the sole of the foot may be necessary (p. 319).

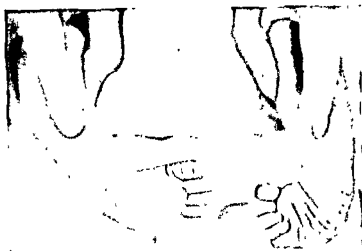


Fig 211. Congenital talipes equinovarus in a baby aged three weeks

The talus is tilted forwards almost out of its socket, its neck is longer and directed more inwards and downwards than usual, and the articular surface of the head faces inwards. The calcaneus is tilted inwards, rotated inwards about its vertical axis, and the concavity of its inner surface is more pronounced. The other bones are not greatly altered in shape although occasionally the navicular is absent.

In untreated or unsuccessfully treated deformities in older children and adults, the inwards and downwards deflection of the neck of the talus is increased, the exposed outer aspect of the head becomes rough and irregular, and the body of the bone wedge-shaped (Fig. 212). The axis of the superior articular facet of the calcaneus is rotated inwards, and the posterior end of the bone remains small reducing the size of the heel. The navicular lies on the inner side of the head of the talus instead of in front of it, and the cuboid is displaced inwards also. There is gross thickening and contraction of the ligaments on the inner side of the foot and ankle, particularly those around the tuberosity of the scaphoid, and there is

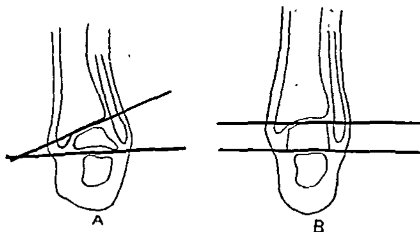



Fig 212 Coronal section of the foot (modified from Walsham and Kent Hughes).
A Distortion of the talus after prolonged weight-bearing
B The normal appearance

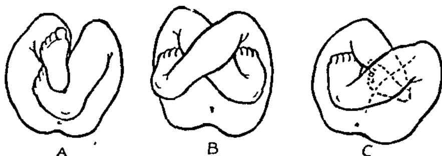



FIG 210 Abnormal intra-uterine positions of the feet (modified from Denis Browne)

into the instep of the other, or one heel is tucked into the opposite groin with the foot in calcaneo-valgus, or the toes are placed in the groin with the foot in equino-varus. Other deformities are explained by less frequent variations such as when the knees are hyperextended and the feet pressed against the forehead. New-born infants fold almost without help into the position they have occupied for so long in the uterus, and the corresponding moulding of the place against which the feet have been pressing is often obvious.

There are two clinical types of talipes—those that are comparatively easily cured and those that are extremely resistant to treatment. It is probable that the former are the result of defects in moulding. In the latter the muscles are atrophic and the joints stiff, and some additional factor must be postulated; Denis Browne explains them, although with less confidence, on a basis of increased mechanical pressure, but other surgeons consider they are due to a primary defect in the development of the muscles.

## TALIPES EQUINOVARUS

This deformity consists of inversion and adduction at the subtaloid *and mid-tarsal joints, and in severe instances at the inter-tarsal*, tarso-metatarsal and metatarso-phalangeal joints also. The appearance of the foot with its small, elevated heel, broad and twisted forefoot, and curved outer border is quite characteristic (Fig. 211). The movements are grossly restricted, even in the new-born, and the foot cannot be made plantigrade without considerable force.

Many infants with normal feet hold them inverted for a while after birth, but there is a full range of passive movements which allows the feet to be dorsiflexed almost until the toes touch the shins, and no treatment is necessary. Care must be taken, however, to recognize very mild talipes in which there is no real deformity but only a little limitation of eversion and dorsiflexion. Such feet require immediate treatment, and they should not be left "to see how they develop" because correction then becomes difficult instead of being simple.

At birth the bones may be normal in shape and size, the deformed position being held only by contracted soft tissues. In more severe cases, however, the bones are distinctly smaller than normal and somewhat distorted in shape. The bones chiefly affected are the talus and calcaneus.

**Babies.** An early start is the first essential as a normal foot is otherwise unobtainable. *The best time to begin treatment is the first day of life.* For a short while the soft tissues are comparatively pliable, there is little or no change in the shape of the bones, and a perfect result is often possible. Adaptive changes in bones and ligaments occur during the first few months and to delay treatment inevitably makes the task harder.

The foot is manipulated to correct both equinus and varus elements of the deformity. An anæsthetic is not required. No great force is necessary but care should be taken to avoid injury to the lower epiphyses of the tibia and fibula. After manipulation the foot is fixed in the greatest amount of eversion and dorsiflexion that can be held without impeding the circulation. This is conveniently done with adhesive strapping as illustrated in Fig. 213.

It is unlikely that a full range of movements will be obtained at the first attempt and manipulation is repeated at intervals of three days until this is achieved. It is not sufficient merely to make the foot plantigrade because relapse is almost certain unless full eversion and dorsiflexion are present. A majority of mild deformities, and some of moderate severity, can be fully corrected within a few weeks; no further treatment is necessary but the child should be kept under observation until he is walking.

If full movements are not obtained within eight weeks, a *Denis Browne splint* is applied. This ingenious instrument controls one foot by means of the other. It not only maintains efficiently the position already obtained, but it increases the range of movements by utilising the muscle power of the legs whilst kicking, and it also helps to reduce the internal torsion deformity of the tibia.

The method of applying the splint is shown in Fig. 214. The cross bar is removed and the leg-plates and the sole-plates are well padded with adhesive felt. First the feet are fastened to the sole-plates with adhesive strapping, then the legs are strapped to the leg-plates, and finally the cross-bar is screwed on and the angle of the feet is adjusted. If both feet are affected, they are turned out about 60°; if only one is affected, it is turned out a similar amount but the normal foot should point straight forwards. The splint requires adjusting every week or so, and its use is continued until full mobility is acquired.

**Infants.** When treatment is started immediately after birth the foot should become normal, if the result is going to be perfect, within a matter of months. Resistant deformities can be greatly improved by subsequent measures and a reasonable functional result can nearly always be obtained by one means or another. It is, however, essential to get the maximum correction as quickly as possible to prevent the deformity of the bones increasing.

The classical treatment at this age consists in repeated forcible manipulation under anæsthesia followed by fixation in plaster-of-Paris. The disadvantages of this procedure are that full correction is seldom, if ever, obtained, and even if walking in plaster is encouraged, the foot gets stiffer, and wasting of the calf muscles increases. Better correction and a more supple foot are obtained by continuing with Denis Browne's method,

contraction of the tendo-Achillis, the posterior capsule of the ankle joint, and the plantar ligaments and fascia. *Wasting of the muscles of the calf* is always conspicuous.

In many instances the tibia is rotated inwards about its longitudinal axis so that the external malleolus is advanced to the coronal plane, or even in front of the internal malleolus (p. 24). This causes the ankle to face slightly inwards, and even after the equinovarus has been corrected, the foot remains in the "intoeing" position.

## Treatment

There is no standard treatment for this deformity, and although there are certain procedures in common use, the indications vary in different clinics. The methods described here are those ordinarily used by the writer.



FIG 213 The first length of adhesive plaster is applied to the heel and second to the forefoot, both are carried around the knee

There has been argument in the past as to the criteria of "cure," but no foot that is abnormal as regards shape, mobility or muscular development can be regarded as cured and it is undesirable to accept a lower standard. A perfect result can by no means always be achieved, and a prognosis cannot be given until the effect of treatment has been seen. As already indicated, there are two clinical types—those that can be cured, and those that are never fully corrected, or quickly relapse. It is probable that relapse only occurs when there has not been full correction, and that once complete mobility has been restored the foot develops normally without further treatment.

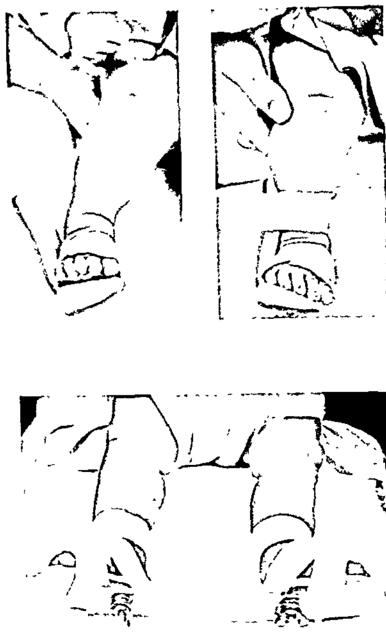


Fig 214 Applying Denis Browne's splint to an infant with bilateral talipes equinovarus. The foot is strapped to the sole-plate before the leg-plate is fixed in position

but substituting open-toed boots for the ordinary footpieces. The splint is removed each day for walking and exercises.

If satisfactory correction is not obtained by two years of age, reduction by open operation is considered. At this age only soft tissue operations are performed, and although they are technically difficult under about thirty months, the earlier they are done, the better is the chance of a good result.

BROCKMAN'S OPERATION aims at freeing or dividing all the soft tissues of the inner and plantar aspects of the middle portion of the foot to enable the bones to be swung into place. All structures including the tendon of tibialis posterior are dissected from the inner and under surfaces of the calcaneus, the head of the talus, the navicular and the first cuneiform bones, and the talo-navicular joint is opened right round. After operation the foot is fixed in a plaster cast with as much correction as is safe, and a fortnight later it is replastered in full eversion. It may be necessary to lengthen the tendo-Achillis and divide the posterior capsule of the ankle at a subsequent operation, and sometimes a rotation osteotomy of the tibia is required. A satisfactory result is often obtained, but in spite of its wide extent the operation is not always entirely successful. This is partly because the shape of the tarsal bones may be altered, and partly because the remaining soft tissues may not yield, especially if they have previously been subjected to repeated forcible manipulations.

**Older Children.** *If a plantigrade foot has not been obtained by three to four years of age,* further manipulations and soft tissue operations usually do more harm than good and an operation on bone is necessary. Forcible moulding of the foot by means of powerful wrenches, vices and screws dates back to the days before aseptic surgery and has no place in modern therapy. Operations on the tarsal bones are best postponed until at least eight years of age when ossification is sufficiently advanced. There is little to be done during the interval except to hold such correction as has already been obtained and keep the foot as supple as possible. During the day a short inside iron, outside T-strap and outside wedges to both sole and heel of the shoe are worn ; at night a metal splint is substituted.

Every foot can be made plantigrade and given useful function by means of a suitable operation on bone. The basic procedure is *Dunn's Triple Arthrodesis* (p. 464); the precise way in which the bones are trimmed varies and each operation is planned to suit the needs of the particular patient. The effect of the operation can be calculated in advance and it is much more satisfactory than "wedge tarsectomy," at one time popular, in which a horizontal wedge with the base facing forwards and outwards is cut across the entire tarsus and removed.

The "boat-shaped" foot that is sometimes produced by forcible dorsiflexion of the forefoot at the mid-tarsal and tarso-metatarsal joints is not easily corrected by triple arthrodesis. This element of the deformity can be improved by lowering the head of the first metatarsal by removing from the base of the bone a wedge with its apex pointing upwards and replacing it with its apex downwards, and lowering the head of the fifth metatarsal by a similar operation on the cuboid.

## CHAPTER VII

# THE SHOULDER GIRDLE

### PAIN IN THE SHOULDER, ARM AND HAND

PAIN referred to the shoulder, arm and hand is a common complaint which is conveniently included here because some of the more usual causes are associated with the shoulder girdle. Although pain is often the first symptom to present itself, and sometimes the only one, the complete syndromes can include objective sensory and motor changes caused by interference with the central or peripheral nervous systems, phenonema due to involvement of the sympathetic nervous system, and vascular disturbances. The following conditions may have to be considered in the differential diagnosis :—

| | |
|---|---|
| *Visceral Disease.* | Pain referred to the shoulder from the pleura, pericardium or diaphragm all of which are supplied by the phrenic nerve (C3, 4 and 5). |
| *Central Nervous System.* | Neoplasms of the cervical cord and nerve roots—pain of root distribution may precede objective signs.<br>Anterior poliomyelitis.<br>Muscle dystrophies.<br>Herpes Zoster.<br>Syringomyelia. |
| *The Spinal Column.* | Spinal caries, neoplasms, fracture of the vertebræ and osteoarthritis.<br>Intervertebral disc protrusion. |
| *Extra-Spinal Disease.* | Pressure at the cervico-brachial junction.<br>Subacromial bursitis and other lesions around the shoulder joint. |

Intervertebral disc protrusion, cervico-brachial pressure and subacromial bursitis are further considered in this chapter. The differential diagnosis between these three is sometimes very difficult, particularly when there are no objective physical signs. The label "brachial neuritis" was formerly attached to many such cases when the ætiology was obscure, but it is now clear that primary brachial neuritis is rare and this diagnosis can no longer be used as a cloak to cover the lack of more precise knowledge.

*Intervertebral Disc Lesions* (p. 279) are often of rapid onset. The symptoms are usually relieved by rest or by head traction ; paræthesiæ

## TALIPES CALCANEUS

This deformity is considerably more common, if mild degrees are included, than is indicated in the table on p. 265. The milder degrees may be caused by one heel being tucked into the opposite groin during intrauterine life (Fig. 210c), and the more severe by some such position as that in which the knees are extended and the soles of the feet pressed against the face.

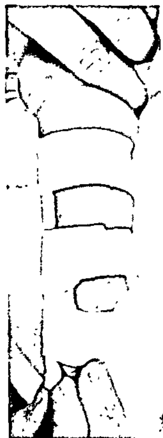


Fig 215

*The deformity consists in acute dorsiflexion* of the foot at the ankle and to a lesser extent at the mid-tarsal joint. Dorsiflexion is usually associated with eversion at the sub-taloid and mid-tarsal joints (*talipes calcaneo-valgus*), and less frequently with inversion at the same joints (*talipes calcaneo-varus*). There is little alteration in the shape of the bones at birth, the deformity being held only by soft tissue contraction. In a moderately bad case the foot cannot be plantar-flexed even to a right-angle without force, the tendons in front of the ankle stand out prominently, and there is no visible longitudinal arch. It should be possible to plantar-flex the normal foot at birth *until the dorsum of the foot is in line with the shin,* and a slight amount of limitation must be watched for because correction is simple only if it is done at once.

### *Treatment*

Treatment, as with talipes equinovarus, should be commenced on the day of birth whilst the soft tissues are still pliable. The foot is manipulated into a position of extreme equinus, and if there is also a valgus element, into moderate inversion. It is held in this position by a straight metal splint fixed to the front of the foot and leg with adhesive strapping (Fig. 215). The prognosis is good when treatment is commenced early and the few resistant cases can be corrected later by operation.

present when there are no symptoms, some other factor must be present, and this is probably concerned with the posture of the shoulder girdle.

## Pathological Anatomy

**Ribs.** The chief abnormalities, of which there are an unlimited number of variations, are :—

(*a*) An additional rib in connection with the seventh cervical vertebra; it may be of any size from a rudimentary projection to a complete rib articulating with the first dorsal rib or sternum (Fig. 216). There may be a fibrous band which lies in the anterior border of the scalenus medius and extends from the tip of a rudimentary rib to the first dorsal rib (Fig. 217). Sometimes there is a large boss or exostosis of the first rib where it is joined by a cervical rib or a fibrous band.

(*b*) A rudimentary first dorsal rib which joins the second rib either directly or by a fibrous band.



Fig 217 Rudimentary cervical ribs At operation on the right side a fibrous band was found joining the tip of the rudimentary rib to the first dorsal rib

(*c*) Asymmetrical first dorsal ribs, usually in association with cervico-dorsal scoliosis.

**Brachial Plexus.** The size of the contribution from the component roots is variable. A post-fixed plexus contains a large element from the second dorsal root.

**Scalene Muscles.** Scalenus Anterior. The costal insertion may be entirely tendinous, it may extend further backwards than usual, and it may have a sharp falciform edge extending posteriorly along the rib.

Scalenus Medius. The costal insertion, which is tendinous, may extend further forwards than usual on the first rib.

It is known that division of the scalenus anterior is sometimes followed by relief from symptoms whether an abnormal rib is present or not. The explanation has been much discussed. It is considered by some surgeons

are restricted to part of the hand, usually the radial side; wasting of the muscles of the hand is unusual, but wasting of the upper arm is common; the biceps or triceps jerks are often diminished or absent; the foraminal compression test may be positive.

*Pressure at the Cervico-Brachial Junction* (see below). The onset of symptoms is gradual, they persist indefinitely and they are not cured by rest; paræsthesiæ are often of glove distribution; pressure above the clavicle may cause pain in the hand; there may be atrophy of the small muscles of the hand; X-rays frequently show abnormalities of the ribs.

*Subacromial Bursitis* (p. 291) is accompanied by limitation of movement at the shoulder with pain at the extreme of movement; there is usually tenderness over some part of the shoulder joint; there may be wasting of the muscles around the shoulder but not of the upper arm or hand, and there are no objective alterations in sensation.



FIG 216 Bilateral cervical ribs. The patient had symptoms in both arms

## PRESSURE AT THE CERVICO-BRACHIAL JUNCTION*

Certain symptoms in the arm and hand, notably paræthesiæ, pain and muscle wasting, are caused by interference with the neurovascular bundle at the root of the neck. A cervical rib is present in many patients with such symptoms, but others have a cervical rib without symptoms, and yet others with typical symptoms have no abnormality of the ribs. A number of theories have been put forward in explanation but it is clear that no single cause can account for all cases. In a majority some variation in the arrangement of the ribs and other structures at the root of the neck can be demonstrated at operation, but since similar variations are often

* This title is given by E D Telford and S Mottershead to their invaluable contribution in the *Journal of Bone and Joint Surgery* (1948, 30B, p 249) of which free use has been made here.

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(*c*) Asymmetrical first dorsal ribs, usually in association with cervico-dorsal scoliosis.

**Brachial Plexus.** The size of the contribution from the component roots is variable. A post-fixed plexus contains a large element from the second dorsal root.

**Scalene Muscles.** SCALENUS ANTERIOR. The costal insertion may be entirely tendinous, it may extend further backwards than usual, and it may have a sharp falciform edge extending posteriorly along the rib.

SCALENUS MEDIUS. The costal insertion, which is tendinous, may extend further forwards than usual on the first rib.

It is known that ...

by re ...

expl ... much discussed. ... is present or not. The ... It is considered by some surgeon...

that this muscle, for an unknown reason, enters a state of spasm which elevates the first rib thus stretching the neuro-vascular bundle. This view is unsupported by evidence and it is more probable that the symptoms are attributable to anatomical variations in the arrangement of the scalene muscles. When the insertion of the scalenus anterior extends unusually far backwards at the same time that the scalenus medius extends forwards, the plexus is raised in the V between them (*Fig.* 218B). In other instances the lowest trunk of the plexus is compressed between the scalenus anterior and the first rib; this may happen when the insertion of the muscle is entirely tendinous, or when there is a boss on the first rib where a cervical rib articulates (*Fig.* 218A).

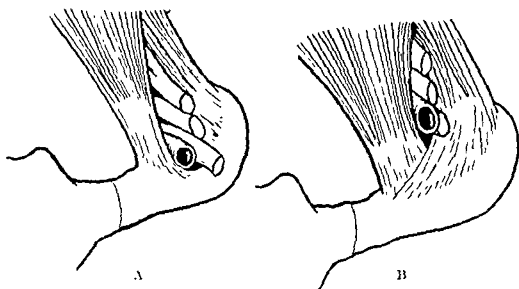



*Fig* 218 Variations in the arrangement of the insertions of the scalene muscles (*redrawn from Telford and Mottershead*)

**Shoulder Girdle.** Drooping of the shoulder girdle appears to be common during middle life, particularly in women, and it is accentuated by unaccustomed manual work or excessive fatigue. It is probable that *this plays an important part in determining the onset of symptoms.*

It has been argued by some writers that depression of the shoulder approximates the clavicle to the first rib, and that the neurovascular bundle is then liable to compressionin the "costo-clavicular vice." This conception is disputed by Telford and Mottershead who have shown experimentally that:—

(*a*) When the arm is abducted or retracted the acromial end of the clavicle rises and moves backwards, and the clavicle rotates so that its concavity arches over the root of the neck. The distance between the clavicle and the first rib is increased.

(*b*) *When the shoulder is depressed the acromial end* of the clavicle moves downwards and forwards increasing the distance between the clavicle and the first rib.

(*c*) *There is no such movement as downward and backward bracing* of the shoulder.

If these *observations are correct, the clavicle cannot compress the*

neurovascular bundle in an individual with normal anatomy. Depression of the shoulder girdle is, however, of importance because (1) it increases the distance covered by the lowest trunk of the brachial plexus, and in some circumstances, particularly when an anatomical abnormality is present, the tension on the plexus becomes great enough to produce symptoms, and (2) it causes compression of the axillary artery between the two heads of the median nerve (see below).

**Axillary Artery.** The radial pulse is diminished or obliterated in certain positions of the shoulder in many patients with a cervical rib, and

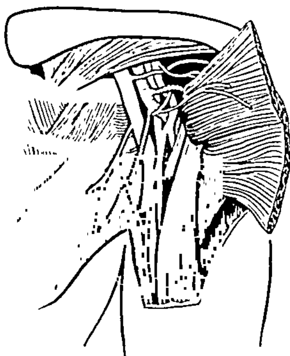


FIG 219 The relations of the axillary artery in 65 per cent of people (redrawn from Telford and Mottershead)

in about 65 per cent of normal subjects. It is unlikely for the reasons already stated that this phenomenon is due to compression of the axillary artery between the first rib and the clavicle. Another explanation is given by Telford and Mottershead who found in a series of anatomical dissections that the two heads of the median nerve, in the same percentage of bodies, were so arranged that the axillary artery was compressed between them when the shoulder was depressed, and in certain other positions of the arm (Fig. 219). In the remaining bodies the arrangement was such that the artery was unaffected by depression of the shoulder.

**Thrombosis.** Thrombosis of the brachial artery is an occasional and grave complication of cervical rib, and in rare instances there is an aneurysmal dilatation of the axillary artery distal to the rib which may be partly or completely thrombosed. The same authors consider both phenomena may be due to arterial spasm caused by irritation of the sympathetic nerve fibres which are sometimes to be found in the lowest trunk of the brachial plexus where it passes over the first rib.

## Clinical Types

**Mild.** There is complaint of burning, tingling and numbness in the hands, frequently both hands. The distribution is of the "glove" type, but it may extend up the forearm and upper arm to the shoulder. Symptoms are usually worse at night, and on waking in the morning the hand may seem "useless." Such complaints, particularly in middle-aged women, have been common since the early years of the last war when so many have undertaken unaccustomed manual work. In cases of this type the ribs are more often normal than abnormal, and it is probable that the symptoms are caused by depression of the shoulder girdle due to fatigue or strain. It is not certain if the symptoms are of nervous or vascular origin but their nature and distribution favours the latter.

**Moderately Severe.** In addition to sensations of numbness and tingling, there is definite pain and often wasting of the small muscles of the hand. Symptoms are frequently unilateral although the other arm may be affected at a later date. The pain comes on in spasms, sometimes almost abruptly, and it is usually worse at night. The distribution is of two types: in one, there is wasting of the thenar eminence and pain or paræsthesiæ over the radial side of the hand and forearm; in the other, the hypothenar eminence and interosseous muscles are atrophied, the fingers become clawed, and there are sensory changes over the ulnar side of the hand and forearm and the inner side of the upper arm. A cervical rib or other structural abnormality at the root of the neck is more often present than absent.

Complete or partial paralysis of the serratus magnus causing winging of the scapula may accompany wasting of the muscles of the hand. Winging also occurs as an isolated phenomenon in the absence of other symptoms and is possibly caused by traction on the long thoracic nerve.

Symptoms due to sympathetic disturbance, such as intense sweating of the palm of the hand, have been observed occasionally and are sometimes the only complaint.

**Very Severe.** There are gross vascular changes and the pain is extremely severe. The brachial vessels may be thrombosed, and sometimes there is an aneurysmal dilatation of the axillary artery distal to the first rib. The dilatation may be partly occluded by thrombus from which fragments become detached causing embolic gangrene of the fingers. Dilatation of the axillary vein has also been observed. Walshe has recorded a complete Horner's syndrome which he considered was due to fibrosis around the stellate ganglion.

## Treatment

Mild subjective sensory symptoms, whether they are associated with anatomical abnormalities or not, are often helped by exercises to strengthen the suspensory muscles of the shoulder girdle. The general health and nutrition of the patient should be investigated, and sometimes a change in occupation is desirable.

More severe pain, muscle atrophy and major vascular disturbances are indications for operation. Operation nearly always relieves pain; it also prevents muscle atrophy from occurring, or if already present from increasing, but existing wasting is not improved. The precise operative procedure cannot be determined in advance because the particular anatomical arrangement that will be encountered is uncertain. The root of the neck should be explored through an adequate incision by a surgeon familiar with the possibilities, and the lesion dealt with as necessary. This may involve excision of a cervical rib or a fibrous band, division of part of one or both of the scalene muscles, removal of a boss of bone from the first rib and occasionally excision of a segment of the first rib.

## CERVICAL DISC PROTRUSION

Cervical intervertebral disc protrusions account for some 6 per cent of all disc protrusions causing symptoms. The pathology is discussed on p. 73. The affected discs are usually those between the fifth and sixth and the sixth and seventh cervical vertebræ, the former being about twice as common as the latter (Spurling).

Cervical disc protrusions produce two distinct syndromes:—

(*a*) Central protrusions causing pressure on the spinal cord. They may present any of the features of a tumour of the cord, and root pain referred to the arm is rare. They will not be further discussed here.

(*b*) Lateral protrusions causing root pressure with symptoms referred to the neck, shoulder and arm. The foramina through which the cervical nerve roots escape from the spinal canal are comparatively small. As the nerves enter the foramina they are in contact with the postero-lateral surfaces of the intervertebral discs, and small lateral protrusions may cause severe symptoms by compressing the nerves against the laminæ or articular facets of the vertebræ.

### Clinical Features

(*Lateral Protrusions*)

It is unusual for the onset to follow immediately after trauma but often there is a history of a much earlier flexion injury to the neck, for example diving into shallow water. Symptoms seldom occur before early middle age. At first there may only be recurring attacks of pain and stiffness in the neck indistinguishable from the ordinary "stiff neck" due to other causes (p. 42). Later, pain may be referred to the shoulder, arm and hand; it is brought on by movement of the neck, or by coughing and sneezing, and typically it is felt at the point of the shoulder and down the arm to the outer side of the elbow. There may be complaint of numbness and tingling in the forearm and hand, or of the hand feeling numb, cold and blue. The symptoms tend to be worse at night and patients often say that they get up several times during the night and walk about. Weakness of the arm and clumsiness in the use of the hand may be noticeable.

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On examination there is usually tenderness over the spinous process at the level of the lesion, and gentle percussion may cause pain referred to the arm. The foraminal compression test is often positive. This test consists in bending the neck towards the painful side and pressing on the top of the head ; when positive it causes pain in the arm. There may or may not be objective sensory changes, muscle atrophy and alteration in the tendon reflexes.



Fig 220 Changes in the fifth and sixth cervical vertebræ accompanying protrusion of the sixth cervical disc

Diagnosis of the level of the lesion is based on the segmental distribution of the symptoms and signs. Pressure on the sixth cervical root, which emerges between the fifth and sixth cervical vertebræ, causes subjective sensations in the thumb and fore-finger, and objective sensory changes over the dorsum of the thumb and first metacarpal, loss of power in the flexors of the elbow, and diminution of the biceps tendon reflex. Pressure on the seventh cervical nerve emerging between the sixth and seventh cervical vertebræ causes subjective sensory changes in the forefinger, middle finger and ring finger, and objective sensory changes over the dorsum of the forefinger, loss of power in the extensors of the elbow, and diminution of the triceps reflex. The sensory distribution of the cervical nerve roots is not very constant and there is a considerable, but variable, overlap of the areas they supply (Fig. 229). The differential diagnosis from other curves of pain in the arm is considered on page 273.

**X-rays.** There is almost invariably some alteration in the normal curve of the cervical spine and narrowing of the affected intervertebral space (Fig. 220). Proliferation of bone at the margins of the bodies of the vertebræ is more constantly present than is the case with lesions affecting the lumbar spine.

### Treatment

A large proportion of patients respond satisfactorily to conservative treatment. As a rule rest in bed with no more than three pillows to support the head and shoulders is sufficient. If pain persists after a few days, traction with a weight of 5-10 lbs. may be applied to the head. This need not be maintained for longer than a week, but rest in bed should be continued for a further fortnight whether or not the symptoms have been relieved earlier. A few patients continue to have some pain after this time and may be provided with a plaster-of-Paris collar or similar support for the neck.

Operation is seldom required but it may be necessary when there is no beneficial response to conservative treatment, or when there are frequent and disabling recurrences. The spinal canal is explored through a small gap made between the adjacent borders of the laminæ and the protruding portion of the disc is removed. The operation is technically difficult but the results are satisfactory.

## STIFF AND PAINFUL SHOULDERS

Lesions around the shoulder joint are amongst the commoner causes of pain in the hand, arm and shoulder girdle. The modern conception of the pathology has developed from the pioneer work of Codman of Boston, and although many problems still remain unsolved, correlation between the pathological and clinical findings is now close enough to be of assistance in planning treatment.

### Movements

Elevation of the arm to the vertical position involves movement at no less than five different sites, three of which are properly constituted joints and two are not. They are :—

1. *The gleno-humeral joint.*
2. *The acromio-humeral, or "bursal joint."*
3. *The scapulo-thoracic mechanism.*
4. *The acromio-clavicular joint.*
5. *The sterno-clavicular joint.*

The gleno-humeral joint, or shoulder joint proper, suffers from few ills. It is a shallow ball and socket joint with a loose capsule and a wide range of movements. No part of the capsule is tense within the ordinary working range, and therefore sprains are rare. The forces operating on the joint, for example the weight of the limb, are usually such as to distract it, not compress it, and this may explain why it is rarely affected by osteoarthritis.

On examination there is usually tenderness over the spinous process at the level of the lesion, and gentle percussion may cause pain referred to the arm. The foraminal compression test is often positive. This test consists in bending the neck towards the painful side and pressing on the top of the head; when positive it causes pain in the arm. There may or may not be objective sensory changes, muscle atrophy and alteration in the tendon reflexes.



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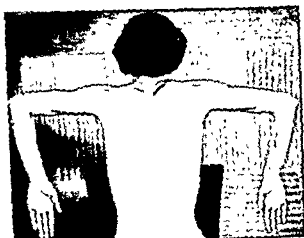


FIG. 222 The limit of abduction of the arms.

*Left:* In internal rotation.

*Top left* · In neutral rotation.

*Top right:* In external rotation



FIG. 223 The limit of elevation of the arms in the sagital plane

*Left:*
In external rotation

*Right*
In internal rotation.



Note the apparent paradox that the final position of the arms is the same when they are elevated in the sagital plane in internal rotation and when they are abducted in external rotation

A peculiarity of the shoulder is that movement at the gleno-humeral joint is necessarily accompanied by movement of the head of the humerus relative to the acromial process ; this takes place at the "bursal joint" (Fig. 224). For practical purposes there is a double joint, and any condition preventing movement at one part must also prevent movement at the other part. Chronic pain and stiffness, however, are nearly always caused by a lesion of the "bursal joint," and very seldom by disorders of the gleno-humeral joint.

It is necessary to distinguish between gleno-humeral and scapulo-thoracic movement during elevation of the arm. The scapula does not lie in the coronal plane but makes an angle of about 30° with it (Fig. 221).

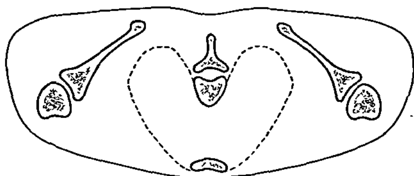


Fig 221 Cross section of the thorax (after Morton, Truex and Kellner)

True abduction takes place in the scapular plane and it is in this plane that movements should be tested. Scapulo-thoracic abduction amounts to about 60° (not 90° as is commonly stated). Gleno-humeral abduction varies in extent with the rotation of the humerus because, in some positions, the tuberosities of the humerus impinge on the acromion and the coraco-acromial ligament. In full internal rotation the range of gleno-humeral abduction is about 50°, and in full external rotation it is more than 120°. Consequently, when the arm is internally rotated, it can only be raised a little above the horizontal (by combined scapulo-thoracic and gleno-humeral movement), whilst in external rotation it can be raised to the perpendicular (Fig. 222). Appreciation of this point is of importance both when examining the movements of the shoulder and when manipulating it under an anæsthetic.

It should be noticed that rotation has a contrary effect when the arm is raised in the sagittal plane (flexion). Full elevation is possible only in *internal rotation, and in external rotation it is restricted to about* 135° (Fig. 223).

Elevation of the normal arm does not consist of two distinct movements, first at the shoulder joint and then at the scapula, but both occur synchronously. This is referred to as the normal scapulo-humeral rhythm. The rhythm is disturbed in pathological conditions of the shoulder.

The function of the supraspinatus muscle is of some clinical importance. It was formerly thought that the supraspinatus initiated the movement of abduction, and the deltoid completed it. This is not so because, when there

the musculo-tendinous cuff bursts into the bursa bringing about a spontaneous relief of symptoms; the calcified material is then rapidly absorbed.

3. Partial Rupture of the musculo-tendinous cuff, almost always the supraspinatus portion, is of considerable clinical importance. It usually occurs in tendons that have already begun to degenerate and may therefore be caused by comparatively trivial injuries. A tear of the deep fibres of the tendon probably produces few symptoms, but a tear of the superficial fibres necessarily involves the floor of the bursa and causes it to become inflamed.

4. Complete Rupture of the musculo-tendinous cuff is usually due to trauma, but it may also occur gradually as the result of a process of attrition without causing acute symptoms. The supraspinatus portion of the cuff is most frequently affected, but the tear may extend into the infraspinatus and subscapularis portions. The rent in the cuff forms a communication between the joint and the bursa, and the head of the humerus is exposed. In the course of time the articular cartilage becomes eroded over this area, and there may also be some peripheral new bone formation giving the appearance of osteoarthritis.

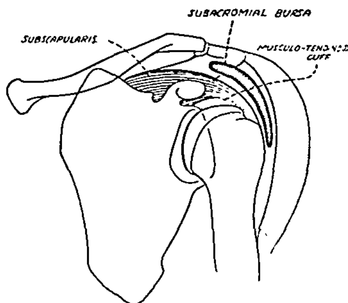



Fig 224 The relations of the subacromial bursa

**The Subacromial Bursa** (Fig. 224). The structures around the shoulder are arranged in two distinct layers (the "bursal joint"). The deep layer consists of the musculo-tendinous cuff and the upper part of the shaft of the humerus; the superficial layer is composed of the deltoid muscle, the under-surface of the acromion, the coracoid process and the coraco-acromial ligaments. Between the layers is interposed the subacromial (subdeltoid) bursa.

The subacromial bursa is a large complicated structure with processes extending under the coracoid process and the neighbouring muscles. It communicates with the joint only in pathological conditions (many subjects

is complete rupture of the supraspinatus, active abduction is still possible, although difficult, provided pain is inhibited by infiltration with novocain. It is probable that the action of the supraspinatus is to depress the head of the humerus in the glenoid during abduction and thus prevent the tuberosities coming into contact with the acromion and the coraco-acromial ligament; the supraspinatus also fixes the head to enable the deltoid to make use of the maximum leverage.

Ankylosis of the acromio-clavicular joint has no demonstrable effect on the function of the arm and the usual anatomical teaching that abduction is restricted is not correct. An ankylosed sterno-clavicular joint, however, restricts scapular movement slightly and prevents full elevation of the arm.

## Pathological Anatomy

**The Musculo-Tendinous Cuff.** The four short rotator muscles of the shoulder, i.e. the supraspinatus, infraspinatus, teres minor and subscapularis, surround the joint on three sides, only the inferior aspect being uncovered. The tendons of these muscles are inserted partly into the tuberosities of the humerus and the sulcus between the tuberosities and the articular surface, and partly into the distal portion of the capsule. They are joined to the capsule so intimately that they can only be separated by cutting and the conjoined tendons and capsule are known as *the musculo-tendinous cuff*, or *rotator cuff*.

Degenerative changes in the cuff are very common after middle age and are almost the rule in manual workers during later life. The cause is not certain but it is probable that trauma is usually responsible. The supraspinatus portion of the cuff is most frequently affected. It is inserted into the highest part of the tuberosity of the humerus and is particularly exposed to repeated minor injuries because it impinges on the acromion *and coraco-acromial ligament when the arm is abducted in internal rotation.*

The following changes are known to occur in the cuff:—

1. Hyaline Degeneration of the tendinous fibres is the earliest pathological change that has been recognized. It causes symptoms when the superficial fibres which lie in contact with the floor of the bursa are affected.

2. Calcified Deposits (Fig. 227) are frequently found in the degenerate tissues of the cuff, but it is not certain that degeneration is an essential pre-requisite to calcification. Some calcified deposits are microscopic in size, others are large enough to show in radiographs as pin-head opacities, and yet others grow to considerable dimensions. A medium-sized deposit can be seen at operation projecting through the musculo-tendinous cuff into the floor of the bursa and looking like a pimple with a yellowish centre surrounded by a red ring of hyperæmia. The deposit is often under tension and on incision the inspissated material is extrudated like tooth-paste from a tube.

Calcification does not take place within the bursa, as Codman once suggested and later denied. Frequently, however, a calcified deposit in

The clinical features of acute lesions are distinctive and an accurate diagnosis is usually possible. It is important for the correct diagnosis to be made at once because the prospect of rapid recovery is greatly improved by early treatment. As already explained, nearly every lesion may cause chronic inflammatory changes in the subacromial bursa; the symptoms are then similar whatever the nature of the primary lesion and treatment is difficult and uncertain. Many patients have been condemned to months of pain because a minor injury of the shoulder was first treated by rubbing with embrocation and resting the arm in a sling.

Radiological examination is always necessary, not only to confirm or exclude the presence of calcified deposits, but also to exclude tuberculosis and other diseases of bone. Osteoarthritis of the gleno-humeral joint is most uncommon. Myofascial tender areas are not infrequently encountered in the trapezius and deltoid muscles; they are recognized by their comparatively superficial situation and the response to infiltration with novocain. Tuberculosis is suggested by gradually increasing stiffness with little pain but gross muscular wasting.

## Complete Rupture of the Cuff

It is probable that this lesion is not uncommon but it is often misdiagnosed and the real incidence is unknown. It occurs typically in middle-aged or elderly manual labourers, but it is also encountered in younger men, in women and in sedentary workers.

The shoulder has usually caused no previous trouble until it is injured by a minor accident such as a fall on the outstretched hand, or a slip when lifting a heavy object. A sharp pain is felt at the time of injury, it gets steadily worse during the next few hours, and by night-time it becomes intolerable and sleep is impossible. The pain may be referred to the neck and down the arm to the hand.

On examination, the arm is held to the side and cannot be abducted actively. Nearly a full range of passive movements can be obtained with care, but this is painful and the pain is greatest as the tuberosity of the humerus passes under the acromion. There is marked tenderness over the cuff, and it may be possible to feel a gap at the site of the tear. Infiltration with novocain abolishes the pain; it also increases the range of active movements, some abduction then being possible although it is weak and cannot be held against pressure.

The symptoms tend to diminish with rest; after a few weeks the patient perhaps returns to work but this soon brings a return of severe pain, particularly during the night. The bursa becomes greatly thickened, sometimes distended with fluid, and the condition becomes predominantly one of chronic subacromial bursitis (see below).

**Treatment.** The prognosis is fair if the tear is sutured within a few days, but it is bad if operation is delayed even for some weeks. When the diagnosis is in doubt it is better to err on the side of excessive zeal and explore the shoulder. Little harm is done if the rupture proves to be only partial, but if a complete rupture is found, the small exploratory incision

for anatomical dissection are elderly and anatomists express a contrary view). It has smooth, glistening inner surfaces which glide freely over one another, and it does not normally contain a demonstrable quantity of fluid. The deep layer of the bursa is closely adherent to the musculo-tendinous cuff and the superficial layer to the under surface of the acromion, and therefore, when the walls of the bursa are inflamed or adherent to each other, movement of the humerus is restricted.

Inflammation is nearly always secondary to a lesion of one of the structures lying in contact with the deep layer of the bursa. It may, therefore, be caused by any of the disorders of the musculo-tendinous cuff described above, and by fracture or disease of the upper end of the humerus. The inflammatory changes are similar to those occurring anywhere else; the inner surfaces of the bursa become red and rough, fluid is excreted, fibrin is deposited, and adhesions are formed. Later the walls become thickened, occasionally to as much as 2 or 3 mms., and the bursa is distended with fluid.

It is doubtful if primary bursitis occurs with any frequency. Stiff and painful shoulders of gradual onset in patients of early middle age are often attributed to "rheumatic" or "toxic" inflammation of the bursa and periarticular tissues. The balance of opinion, however, is against any such localized "rheumatic" manifestation and primary bursitis is probably a rarity.

**The Biceps Tendon.** The tendon of the long head of the biceps arises from the scapula just above the glenoid cavity; it passes across the upper part of the joint within the capsule, emerges between the greater and lesser tuberosities, and then lies in the bicipital groove on the front of the humerus. It is not connected with the capsule but is invaginated into the synovial membrane, a sheath of which extends down the tendon towards the belly of the muscle for some two inches. The tendon does not move when the biceps contracts provided the shoulder joint is kept still, but movement of the humerus relative to the scapula is always accompanied by movement of the tendon in the bicipital groove.

Degenerative changes similar to those in the musculo-tendinous cuff may take place with increasing age. The tendon becomes frayed and attenuated where it is angulated round the upper end of the humerus, and then it is liable to be ruptured by a comparatively minor strain such as lifting a heavy weight or falling onto the outstretched hand. Sprain of the healthy tendon or the peri-tendinous tissues also occurs in younger people from violent traction injuries.

## Clinical Types

The following types may be distinguished :—

*Complete rupture of the cuff.*
*Partial rupture of the cuff.*
*Calcified deposits in the cuff.*
*Bicipital tenovaginitis.*
*Chronic subacromial bursitis.*

The clinical features of acute lesions are distinctive and an accurate diagnosis is usually possible. It is important for the correct diagnosis to be made at once because the prospect of rapid recovery is greatly improved by early treatment. As already explained, nearly every lesion may cause chronic inflammatory changes in the subacromial bursa; the symptoms are then similar whatever the nature of the primary lesion and treatment is difficult and uncertain. Many patients have been condemned to months of pain because a minor injury of the shoulder was first treated by rubbing with embrocation and resting the arm in a sling.

Radiological examination is always necessary, not only to confirm or exclude the presence of calcified deposits, but also to exclude tuberculosis and other diseases of bone. Osteoarthritis of the gleno-humeral joint is most uncommon. Myofascial tender areas are not infrequently encountered in the trapezius and deltoid muscles; they are recognized by their comparatively superficial situation and the response to infiltration with novocain. Tuberculosis is suggested by gradually increasing stiffness with little pain but gross muscular wasting.

### Complete Rupture of the Cuff

It is probable that this lesion is not uncommon but it is often misdiagnosed and the real incidence is unknown. It occurs typically in middle-aged or elderly manual labourers, but it is also encountered in younger men, in women and in sedentary workers.

The shoulder has usually caused no previous trouble until it is injured by a minor accident such as a fall on the outstretched hand, or a slip when lifting a heavy object. A sharp pain is felt at the time of injury, it gets steadily worse during the next few hours, and by night-time it becomes intolerable and sleep is impossible. The pain may be referred to the neck and down the arm to the hand.

On examination, the arm is held to the side and cannot be abducted actively. Nearly a full range of passive movements can be obtained with care, but this is painful and the pain is greatest as the tuberosity of the humerus passes under the acromion. There is marked tenderness over the cuff, and it may be possible to feel a gap at the site of the tear. Infiltration with novocain abolishes the pain; it also increases the range of active movements, some abduction then being possible although it is weak and cannot be held against pressure.

The symptoms tend to diminish with rest; after a few weeks the patient perhaps returns to work but this soon brings a return of severe pain, particularly during the night. The bursa becomes greatly thickened, sometimes distended with fluid, and the condition becomes predominantly one of chronic subacromial bursitis (see below).

**Treatment.** The prognosis is fair if the tear is sutured within a few days, but it is bad if operation is delayed even for some weeks. When the diagnosis is in doubt it is better to err on the side of excessive zeal and explore the shoulder. Little harm is done if the rupture proves to be only partial, but if a complete rupture is found, the small exploratory incision

for anatomical dissection are elderly and anatomists express a contrary view). It has smooth, glistening inner surfaces which glide freely over one another, and it does not normally contain a demonstrable quantity of fluid. The deep layer of the bursa is closely adherent to the musculo-tendinous cuff and the superficial layer to the under surface of the acromion, and therefore, when the walls of the bursa are inflamed or adherent to each other, movement of the humerus is restricted.

Inflammation is nearly always secondary to a lesion of one of the structures lying in contact with the deep layer of the bursa. It may, therefore, be caused by any of the disorders of the musculo-tendinous cuff described above, and by fracture or disease of the upper end of the humerus. The inflammatory changes are similar to those occurring anywhere else; the inner surfaces of the bursa become red and rough, fluid is excreted, fibrin is deposited, and adhesions are formed. Later the walls become thickened, occasionally to as much as 2 or 3 mms., and the bursa is distended with fluid.

It is doubtful if primary bursitis occurs with any frequency. Stiff and painful shoulders of gradual onset in patients of early middle age are often attributed to "rheumatic" or "toxic" inflammation of the bursa and periarticular tissues. The balance of opinion, however, is against any such localized "rheumatic" manifestation and primary bursitis is probably a rarity.

**The Biceps Tendon.** The tendon of the long head of the biceps arises from the scapula just above the glenoid cavity; it passes across the upper part of the joint within the capsule, emerges between the greater and lesser tuberosities, and then lies in the bicipital groove on the front of the humerus. It is not connected with the capsule but is invaginated into the synovial membrane, a sheath of which extends down the tendon towards the belly of the muscle for some two inches. The tendon does not move when the biceps contracts provided the shoulder joint is kept still, but movement of the humerus relative to the scapula is always accompanied by movement of the tendon in the bicipital groove.

Degenerative changes similar to those in the musculo-tendinous cuff may take place with increasing age. The tendon becomes frayed and attenuated where it is angulated round the upper end of the humerus, and then it is liable to be ruptured by a comparatively minor strain such as lifting a heavy weight or falling onto the outstretched hand. Sprain of the healthy tendon or the peri-tendinous tissues also occurs in younger people from violent traction injuries.

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*Partial rupture of the cuff.*
*Calcified deposits in the cuff.*
*Bicipital tenovaginitis.*
*Chronic subacromial bursitis.*

**Treatment.** Early active treatment is essential to prevent the shoulder becoming stiff. If pain is severe, rest may be necessary for a few days, preferably in a splint in abduction and external rotation. Many abduction splints fail to provide for external rotation, but this position is important to prevent the injured part of the cuff from coming into contact

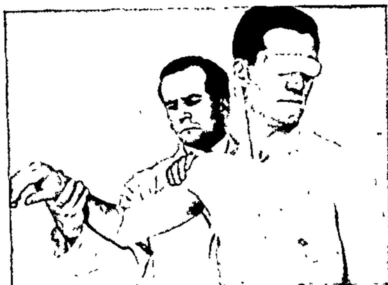


FIG. 226.

with the acromion. With less severe pain the arm may be kept in a sling, but external rotation should be ensured by a large pad of wool placed in the angle between the forearm and trunk. Cold packs applied to the shoulder are often of more help in relieving pain than is warmth.

Active movements should be commenced as soon as possible. They are carried out with the body bent and the arm hanging free, and also standing upright using a rope and overhead pulley, and with a towel, as in drying the back. Passive movements should be made once each day, even if painful, through the greatest possible range. Passive abduction is facilitated by pressure over the upper end of the humerus to depress the head in the glenoid cavity (Fig. 226). Infiltration with novocain immediately before commencing treatment is of great assistance and appears to speed recovery.

## Calcified Deposits

These usually occur in the supraspinatus portion of the musculotendinous cuff, and less frequently in the subscapularis and infraspinatus portions. The deposits are often symptomless and may only be discovered during radiological examination for some other condition.

Symptoms are caused when the deposit impinges on the floor of the subacromial bursa. Occasionally the onset is rapid, but as a rule there is at first only an occasional pain or ache in the shoulder. Later abduction becomes painful, typically during the mid-part of the range only, and the remainder of the movement is painless ; active movements are restricted to a greater extent than passive. There is tenderness over the affected area.

can be extended and the tendon repaired. After repair the arm is fixed in a plaster spica in a position of abduction 90° and external rotation 45°. A lid is removed from the plaster over the arm three weeks later and movements are commenced (Fig. 225). The plaster is not discarded until active elevation of the arm is possible, probably about ten to twelve weeks.



Fig 225 Note that the humerus is in the scapular plane

Chronic lesions are treated as for chronic subacromial bursitis. The response to conservative measures is often unsatisfactory; excision of the acromion sometimes helps and is worth a trial but arthrodesis may be the only method of relieving the pain.

## Partial Rupture of the Cuff

*Codman found this lesion in a large percentage of autopsies on elderly* people. It is much more frequent than is generally recognized and is one of the common causes of pain in the shoulder of sudden onset. It usually occurs, sometimes without noticeable trauma, in tendons already weakened by degeneration.

The history resembles that in complete rupture. A sharp pain is felt in the shoulder which gradually gets worse and may be referred down the arm. Active abduction up to about 60° without pain is often possible, and there is a fair range of movements in the stooping position with the arm hanging free. Manual depression of the head of the humerus in the glenoid increases the range of passive abduction. There is tenderness over the supraspinatus portion of the cuff. Infiltration with novocain relieves the pain and restores almost full movement with good power; this is a valuable diagnostic and therapeutic procedure.

There is a greater liability to adhesive bursitis after partial rupture than after complete rupture, and treatment must be commenced early or the condition rapidly deteriorates and becomes chronic. The symptoms, signs and treatment are then as for chronic subacromial bursitis

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Inflammatory changes often develop in the bursa after a time and give rise to symptoms of chronic bursitis which merge with those due to the calcified deposit. Not infrequently, however, there is spontaneous rupture of the deposit into the bursa with immediate and lasting relief.

**Treatment.** The presence of a calcified deposit causing symptoms is an indication for operation (p. 227). Although spontaneous cure may occur, there is no way of telling if this will be in days or years and most patients are glad enough to accept an operation rather than face an uncertain period of pain and disability. Treatment is unnecessary when deposits are discovered by chance and there are no symptoms.



FIG 227 Calcified deposit in the musculo-tendinous cuff

## Biceps Tendon Injuries

**Bicipital Tenovaginitis.** Inflammation of the synovial sheath covering the upper part of the biceps tendon occurs, usually in a healthy young person, as the result of a violent traction injury rupturing a few fibres of the tendon. It may also be caused by very vigorous use of the arm without any specific injury.

*There is complaint of pain in the shoulder which is made* worse by flexing the elbow, or by supinating the forearm against resistance. Tenderness is localized to the upper part of the bicipital groove. Movements, particularly abduction and external rotation, may be restricted. Faradic stimulation of the long head of the biceps causes pain, whereas stimulation of the short head does not. The condition subsides with rest.

**Complete Rupture of the Biceps Tendon.** This injury usually occurs where the tendon passes round the head of the humerus, or where it joins the muscle belly. The appearance is characteristic; on flexing the elbow or supinating the forearm against resistance, the biceps fails to harden as it should and the bulge of the muscle belly is lower in the arm than usual (Fig. 228). Symptoms are not as a rule serious; there is but little pain and the slight loss of power interferes only with heavy manual work.

TREATMENT. Operation, which is only sometimes necessary, gives satisfactory results. No attempt is made to repair the tendon or to retrieve the proximal end which is loose in the joint. It is sufficient to anchor the distal end of the tendon to the humerus as high up as possible, or alternatively to attach it to the conjoined tendon of the coraco-brachialis and short head of the biceps.



FIG. 228 Rupture of the long head of biceps

## Chronic Subacromial Bursitis

Chronic pain and stiffness of the shoulder is most
subacromial bursitis. The bursitis is secondary to a pr
is usually in the musculo-tendinous cuff, and sometimes in the humerus (p 285). The clinical picture when fully developed is similar whatever the cause, and often the nature of the primary lesion can be deduced only from the history; when the onset is gradual the cause is usually to be found in degenerative changes in the superficial fibres of the cuff, but a sudden onset suggests complete or partial rupture of the cuff.

**Signs and Symptoms.** The outstanding features are pain, limitation of movement and tenderness.

PAIN. When the onset is gradual, pain is first felt deep in the shoulder, and it is often referred to the region of the insertion of the deltoid as well. It increases slowly in intensity and becomes noticeable on movements involving abduction and external rotation, such as doing the hair. Sometimes pain is experienced only over part of the range of abduction, usually

about 45° to 90°, movement below and above being painless; this is typical of a localized lesion of the cuff such as a calcified deposit.

In time the pain may become so severe as to be almost unbearable. It radiates up the neck, into the shoulder blade and down the arm, wrist and fingers. The arm is held with the elbow to the side and the hand across the chest, a position of adduction and internal rotation. Interference with sleep at night is characteristic and this is often the complaint that troubles the patient most.

The muscles around the shoulder are supplied by the fifth to eighth cervical roots, and pain may be referred anywhere within the cutaneous distribution of these roots (Fig. 229). Pain in the hand is most frequently

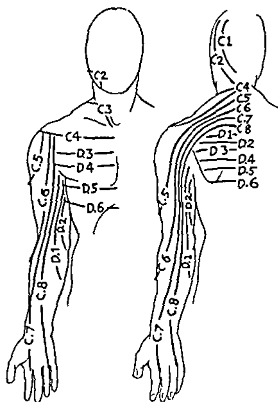



FIG 229 Cutaneous distribution of the cervical nerve roots (after Bing)

felt in the ring and middle fingers. Pain at the insertion of the deltoid is almost pathognomonic of subacromial bursitis. The distribution of pain has often lead to an erroneous diagnosis of "brachial neuritis" but the mistake can be avoided by examining the shoulder whenever there is pain in the arm or hand. The differential diagnosis from other causes of pain in the arm is discussed on p. 273.

LIMITATION OF MOVEMENT may be slight at first, only the extreme of one movement being checked by pain. It increases as the walls of the subacromial bursa become adherent and adhesions form in the musculotendinous cuff, until finally all movement at the gleno-humeral joint may disappear. Most patients are wary of actions requiring abduction or external rotation—when undressing they remove the good arm first from their

coats and shirts. Active movements are often restricted to a greater extent than passive.

Examination of the range of movements requires care because scapulo-thoracic movement may mask gleno-humeral. The patient should be undressed to the waist and viewed from behind. The scapulo-humeral rhythm is altered in all but the mildest cases, and instead of the arm and shoulder moving harmoniously, the scapula is elevated first and then the humerus is raised laboriously. When examining active movements it is easier to separate shoulder from scapular movement if the patient raises both arms at the same time. When testing passive movements there should be complete muscular relaxation and the scapula is fixed with one hand whilst the arm is slowly lifted with the other. This is done as shown in Fig. 226 but the left hand should rest on the acromion instead of on the upper part of the arm.

Tenderness. There is always tenderness over the site of the primary lesion, and if the bursa is greatly inflamed or distended with fluid, the whole region is tender. In supraspinatus lesions, and these are the commonest, tenderness is localized to a point just below the acromion and a little towards the front of the shoulder. Rotation of the humerus whilst pressure is maintained moves the tender spot from under the examining finger, and thus establishes the fact that the lesion is in the rotator cuff and not in the superficial muscles. Tenderness of the bicipital groove can also be localized during rotation of the arm.

Wasting. Some wasting of the supraspinatus and infraspinatus muscles occurs fairly early in severe cases, but it is not conspicuous and is hard to see in fat patients. Wasting of the deltoid is seldom noticeable until late. Gross wasting with a stiff but comparatively painless shoulder is characteristic of tuberculosis.

**Treatment.** Owing to the varying nature of the primary lesion, treatment is uncertain and it is difficult to give an accurate prognosis. Some patients respond well but others are more resistant, and although ultimate recovery is the rule, severe lesions may take as long as a couple of years. The prognosis with untreated complete rupture of the rotator cuff is rather gloomy and there may be permanent pain and incapacity.

Physiotherapy. Heat in any of its forms does not appear to be of great value although muscle spasm may be reduced by warming the shoulder with an infra-red lamp and massaging the superficial muscles. Short-wave diathermy occasionally helps, but often it intensifies the pain.

Movements, both active and passive, play an important part in treatment. Active movements are carried out as outlined on p. 289 for the treatment of recent injuries. Infiltration with novocain immediately before commencing treatment is most helpful because it increases the range of painless movement.

It is unusual for pain to be relieved completely and permanently until the full range of movements has been restored. It is easy to be deceived about the return of gleno-humeral movement because it is partly masked by scapulo-thoracic movement. A useful check, and also a good exercise,

is as follows: the patient stands with his back to a wall and keeps his heels, buttocks, shoulders and elbows in contact with it whilst he abducts both arms to 90° and then externally rotates them—he should be able to touch the wall with the backs of the hands (Fig. 230).

MANIPULATION under anæsthetic is helpful after the acute symptoms have subsided, but if performed too early it often aggravates them. The best results are obtained when only one or two adhesions give way, and the worst results when the shoulder moves with a nasty feeling like rubbing wet wash-leather. A useful indication of the best time to manipulate is when the patient can sleep lying on the affected side. With very stiff joints it is better to repeat the manipulation several times obtaining only a few degrees of movement at each, than to move the shoulder through the full range at one session and produce a severe reaction.

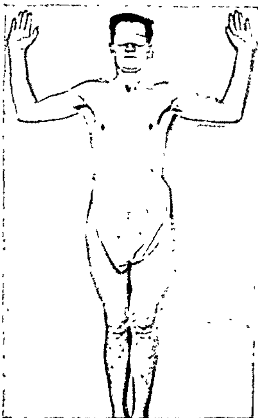


FIG 230

During manipulation it is important to remember the normal movement of the shoulder because serious damage to the capsule may be caused by forcible abduction without the corresponding amount of external rotation. The patient lies supine throughout the procedure. The first movement is distraction; the operator's knee is placed against the axillary border of the scapula and traction exerted in the longitudinal axis of the humerus. Next, the scapula is fixed by pressure with one hand, the upper arm is supported on the operator's knee and the humerus is moved first into internal rotation, and then into external rotation and abduction (Fig. 231). The arm should be held by the elbow, and not by the forearm, in order to keep the leverage small and reduce the risk of fracturing the humerus. The final movement is adduction and for this the scapula is fixed by hooking the fingers of one hand round its vertebral border.

OPERATION. It is not always easy to decide the best time to operate and as a rule it is necessary to await the response to conservative treatment. Operation should be considered when there is long-continued severe pain, and when the patient is prevented from following his usual occupation, particularly if he is becoming mentally depressed. Sometimes operation is desirable when the symptoms are less severe. One of my patients had only a single symptom, pain at the extreme of external rotation, but his hobby was rock-climbing; manipulation was without effect and division of a single thread-like adhesion at open operation was successful. At the other

extreme was a signalman who was incapacitated by a resistant bursitis due to a neglected complete rupture of the cuff; he returned to work after arthrodesis. The presence of calcified deposits causing symptoms, and gross thickening of the bursal sac are both indications for operation.

*Exploration of the Bursa* is carried out through a 2 inch incision over the antero-lateral aspect of the shoulder. The fibres of the deltoid are separated and the roof of the bursa opened; the greater part of the musculo-tendinous cuff can be brought opposite the wound for examination by rotating the humerus. The operation proceeds according to the lesion found; calcified deposits may be removed, adhesions divided, and the bursa, or part of it, excised. An old complete rupture of the cuff is very

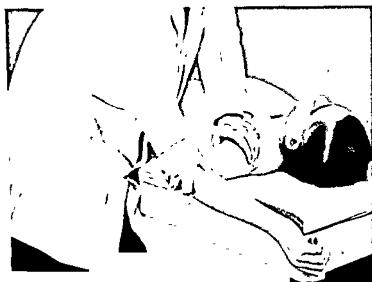


Fig 231 When manipulating the shoulder external rotation must precede abduction

difficult to repair and the results have been satisfactory only in isolated instances.

*Excision of Acromion* is reported as being a useful procedure in severe cases with thickening of the bursa, and even with complete rupture of the cuff, but the writer's experience of the operation has not been encouraging. The purpose of the operation is to remove the bony roof of the "bursal joint" which may be interfering with movement. The entire acromial process is excised through a "sabre-cut" incision and the deltoid muscle re-attached to the stump; the bursa and the outer portion of the coraco-acromial ligament should be removed at the same time.

*Arthrodesis* of the gleno-humeral joint is performed as a last resort in patients with incapacitating pain which has resisted all conservative treatment. The resulting disability is less than might be expected because scapulo-thoracic movement is not interfered with. The patient is able to get his hand to his mouth and to the back of his head, and to manage many kinds of work.

The best position in which to fix the shoulder in an adult is 60° of abduction in the scapular plane, and neutral rotation. The amount of

is as follows: the patient stands with his back to a wall and keeps his heels, buttocks, shoulders and elbows in contact with it whilst he abducts both arms to 90° and then externally rotates them—he should be able to touch the wall with the backs of the hands (Fig. 230).

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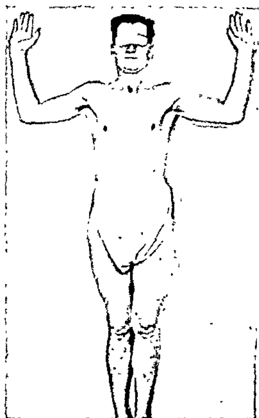


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significance of this in relation to the ætiology of recurrent dislocation is still uncertain.

The reason why some dislocations of the shoulder heal without causing further trouble whilst others recur has been the subject of much speculation. Bankart maintains that it is because the nature of the lesion is different. He considers that in non-recurring dislocations the head of the



FIG 233 Defect of the head of the humerus in a patient with recurrent dislocation of the shoulder.

humerus passes through a rent in the joint capsule which heals rapidly, whilst in recurring dislocations the glenoid ligament is detached and cannot re-adhere because of its poor vascularity. This view is disputed by many surgeons who think that the initial lesion is always a detachment of the glenoid ligament, and that when the dislocation recurs it is because the arm has not been immobilized for long enough to allow the injury to heal.

The pathology is of more than academic importance because, if Bankart's theory is accepted, it is unnecessary to immobilize the arm the first time the shoulder is dislocated; but if the other theory is correct, immobilization is essential. The safe practice is to immobilize the arm for three weeks after the initial dislocation in a young person. In older people the shoulder so often becomes stiff when immobilized that the comparatively small risk of the dislocation recurring may be accepted and early movements prescribed.

A defect in the postero-lateral aspect of the head of the humerus is demonstrable radiologically in many patients with recurrent dislocation, but not in all (Fig. 233). It is visible only in films taken whilst the shoulder is internally rotated about 60°, and since this is not a routine view in all departments of radiology, the incidence reported by different observers

rotation can be checked on the operating table by flexing the elbow which should bring the hand to the mouth. The joint is approached through a curved incision passing over the top of the shoulder and down the front of the arm. The articular cartilage is removed from the opposing surfaces

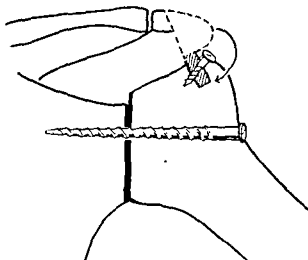


Fig 232 Arthrodesis of the shoulder

of the joint which are then fixed in apposition with a long screw or a tri-fin nail. *The acromial process is "broken" downwards and its tip fastened into* a slot cut in the greater tuberosity (Fig. 232). A plaster-of-Paris spica is applied and worn for three months by which time union is usually secure.

## RECURRENT DISLOCATION OF THE SHOULDER

This is a condition in which dislocation of the gleno-humeral joint recurs with some frequency. The initial dislocation is clinically indistinguishable from an ordinary dislocation sustained perhaps at football, or during an epileptic fit, but instead of recovering as usual the joint re-dislocates from time to time. Re-dislocation occurs without great violence when abducting or extending the arm, even during such ordinary movements as brushing the hair. It may happen only at widely-spaced intervals, or it may be so frequent as to interfere with ordinary activities. The patient is often able to reduce a re-dislocation himself, or with amateur assistance, but sometimes an anæsthetic is required.

### Pathological Anatomy

The typical lesion as seen at operation consists in a separation of the antero-inferior portion of the glenoid ligament from the glenoid cavity. Sometimes the capsule is detached from the glenoid ligament, the latter remaining joined to the bone, and sometimes the ligament is free from both capsule and bone, rather like a bucket handle tear of the internal meniscus of the knee. There is usually a well-defined area in front of the neck of the *scapula and beneath the subscapularis muscle into which the head of the* humerus is displaced when it is dislocated. A somewhat similar defect in the attachment of the antero-inferior portion of the capsule is known to occur in a high proportion of apparently normal people, but the exact

edge of the articular cartilage to emerge in the bicipital groove about 1½ inches lower. The biceps tendon is divided, the proximal end is passed through the hole and the divided ends are sutured (Fig. 234).

PUTTI-PLATT OPERATION. The shoulder is approached anteriorly by severing the clavicular portion of the deltoid close to its origin, detaching

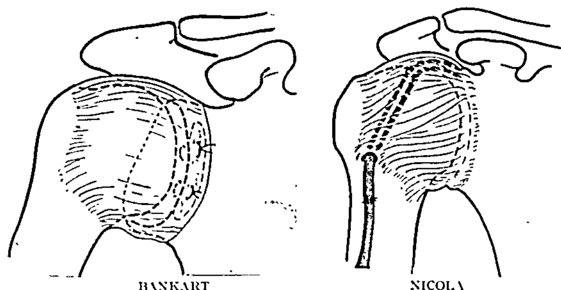



FIG 234 Operations for recurrent dislocation of the shoulder

the conjoined tendon of the coraco-brachialis and short head of the biceps from the coracoid process, and dividing the upper inch of the tendon of the pectoralis major; the subscapularis is cut one inch from its insertion and retracted medially. Repair is effected by fixing the short distal stump of the subscapularis in front of the joint, overlapping this with the proximal part of the capsule, and finally drawing the proximal end of the subscapularis over everything and suturing it in the region of the greater tuberosity of the humerus. This operation is successful in making the front of the joint secure and preventing re-dislocation, but abduction and external rotation are permanently restricted.

## THE ACROMIO-CLAVICULAR JOINT

There is very little movement at this joint and when it is ankylosed there is no demonstrable change in the range of movement of the shoulder girdle or of the gleno-humeral joint. The common disorders to which it is liable are sprain, osteoarthritis and dislocation.

Sprains are the result of direct injury and occur with fair frequency. Osteoarthritis causing symptoms is less common than is often assumed but typical changes can occasionally be demonstrated radiographically. Both conditions can easily be confused with lesions of the musculo-tendinous cuff because they may cause limitation of movement at the shoulder and pain referred down the arm. In acromio-clavicular lesions, however, tenderness is accurately localized to the joint and pain is caused by adduction of the arm across the front of the chest. Treatment consists in physiotherapy and novocain infiltration, but osteoarthritic joints may require arthrodesis.

varies considerably. The cause of the defect is not fully understood, but the importance is that, during external rotation and abduction, the defective part of the head comes opposite the antero-inferior margin of the glenoid cavity and allows the head to slip over it. Therefore, when a defect is present, dislocation takes place more easily.

Some patients sustain their initial dislocation without any greater violence than, say, bowling at cricket. It is probable that this occurs only when there is a defect of the head which is then able to slip over the margin of the glenoid whilst still remaining within the capsule. The injury is more in the nature of a subluxation than a true dislocation and the capsule is not necessarily torn or detached from the bone.

## Treatment

Recurrent dislocation can only be dealt with satisfactorily by operation. Operation is indicated when dislocation recurs with sufficient frequency to be troublesome, and when the occupation of the patient demands it. A sedentary worker who does not play games may not worry about a shoulder that goes out only every few years, but it is a real handicap to a house decorator or a tennis player. When operation is contra-indicated on general grounds, or refused by the patient, abduction can be restricted by an apparatus consisting of straps round the chest and arm joined by a link passing through the armhole of the coat.

Nearly a hundred operations or variations of operations for the cure of this condition have been described, but most have fallen into disuse. The "sling" type such as Clairmont's, which are intended to hold up the shoulder from below, and "bone block" operations designed to prevent forward dislocation by fixing a bone graft to the neck of the scapula or the coracoid process are seldom used. Those now most frequently performed for complete dislocation are Bankart's and Nicola's; for recurrent subluxation with a defect in the head of the humerus it is desirable to restrict external rotation permanently, and therefore a procedure of the Putti-Platt type may be preferable.

Bankart's Operation is the only operation that restores the anatomy of the shoulder to normal and gives consistently good results and perfect function of the shoulder. It has not been adopted universally, perhaps because of its technical difficulty, but it is becoming the operation of choice of an increasing number of surgeons. Through an anterior incision the coracoid process is divided and reflected downwards together with the muscles attached to it, the subscapularis is divided and retracted inwards, the margin of the glenoid cavity is excoriated and the joint capsule is stitched to it (Fig. 234).

Nicola's Operation does not repair the defect but uses the tendon of the long head of the biceps as a check ligament. The results on the whole are good, but there is some permanent limitation of abduction, and subluxation may not be controlled, and in time the tendon may fray and rupture thus permitting re-dislocation. The upper end of the humerus is exposed through an anterior incision and a hole is drilled from near the

edge of the articular cartilage to emerge in the bicipital groove about $1\frac{1}{2}$ inches lower. The biceps tendon is divided, the proximal end is passed through the hole and the divided ends are sutured (Fig. 231).

Putti-Platt Operation. The shoulder is approached anteriorly by severing the clavicular portion of the deltoid close to its origin, detaching

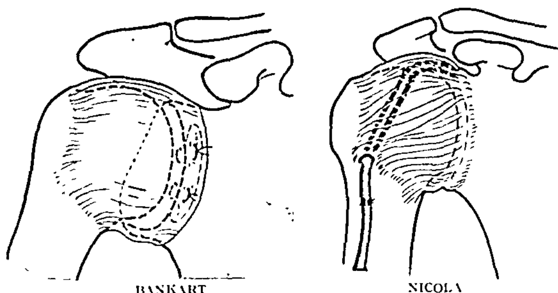



Fig 231 Operations for recurrent dislocation of the shoulder

the conjoined tendon of the coraco-brachialis and short head of the biceps from the coracoid process, and dividing the upper inch of the tendon of the pectoralis major ; the subscapularis is cut one inch from its insertion and retracted medially. Repair is effected by fixing the short distal stump of the subscapularis in front of the joint, overlapping this with the proximal part of the capsule, and finally drawing the proximal end of the subscapularis over everything and suturing it in the region of the greater tuberosity of the humerus. This operation is successful in making the front of the joint secure and preventing re-dislocation, but abduction and external rotation are permanently restricted.

## THE ACROMIO-CLAVICULAR JOINT

There is very little movement at this joint and when it is ankylosed there is no demonstrable change in the range of movement of the shoulder girdle or of the gleno-humeral joint. The common disorders to which it is liable are sprain, osteoarthritis and dislocation.

Sprains are the result of direct injury and occur with fair frequency. Osteoarthritis causing symptoms is less common than is often assumed but typical changes can occasionally be demonstrated radiographically. Both conditions can easily be confused with lesions of the musculo-tendinous cuff because they may cause limitation of movement at the shoulder and pain referred down the arm. In acromio-clavicular lesions, however, tenderness is accurately localized to the joint and pain is caused by adduction of the arm across the front of the chest. Treatment consists in physiotherapy and novocain infiltration, but osteoarthritic joints may require arthrodesis.

## Acromio-Clavicular Dislocation

The integrity of the acromio-clavicular joint depends upon the coraco-clavicular and coraco-acromial ligaments and the joint cannot be completely dislocated unless both these ligaments are ruptured. Such an injury may be caused by a fall or a blow on the point of the shoulder. The clinical appearance is characteristic; the acromion is pulled downwards

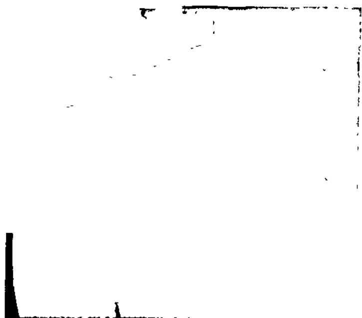


Fig 235 Acromio-clavicular dislocation

by the weight of the arm and there is an obvious step about half an inch deep at the site of the joint (Fig. 235). X-rays do not show the defect when taken with the patient lying unless the arm is pulled downwards. Subluxation occurs when there is only partial rupture of the ligaments and then the deformity, if any, is less obvious.

**Treatment.** Conservative. At first there may be pain, swelling and bruising due to the ligamentous injury, but this soon subsides. The dislocation is readily reduced by raising the arm; it is difficult to hold the reduction and it is customary to attempt it by encircling shoulder and elbow with strips of adhesive strapping, but this stretches and a new layer has to be added every day or two. A simple and effective method of fixation is to use webbing straps arranged as shown in Fig. 236; the tension is increased as required by tightening the strap round the chest. Fixation has to be maintained for about six weeks during which time the joint must not be allowed to separate even momentarily. *The ligaments reform* reasonably well although they do not become sufficiently taut to prevent all deformity; the function of the arm is, however, excellent and the cosmetic result fairly good.

Operative. Function, even with an untreated complete dislocation, is seldom greatly impaired and operation is not often necessary. It is, however, indicated occasionally in heavy manual workers or athletes on account of weakness.

There are two types of operation, arthrodesis of the acromio-clavicular joint and reconstitution of the acromio-clavicular ligament.

*Arthrodesis.* The acromio-clavicular joint is transfixed with three or four short lengths of Kirschner wire. The wires can be introduced through puncture wounds, or alternatively the joint may be exposed and the articular cartilage removed before inserting the wires. The cosmetic and functional results are said to be good.

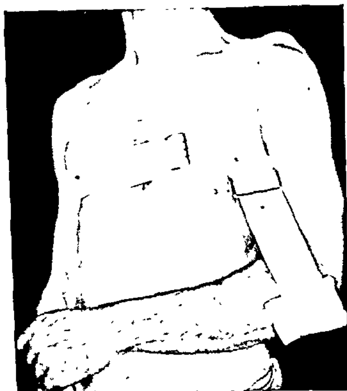


Fig 236 Webbing straps are a convenient method of supporting a dislocated acromio-clavicular joint

*Reconstitution of the Ligament.* Several techniques have been evolved, as a rule using fascia lata passed around the corocoid process and through holes drilled in the clavicle. This type of operation restores the strength of the shoulder and diminishes, but never completely abolishes, the deformity.

## THE STERNO-CLAVICULAR JOINT

**Ankylosis.** Movement at this joint is essential for a full range of movements at the shoulder girdle. Ankylosis occasionally occurs as the result of rheumatoid or gonococcal arthritis and then the excursion of the scapula is somewhat reduced. The full range can be restored, should it be necessary, by excising a segment of the clavicle.

**Dislocation.** This is an uncommon accident which is usually caused by indirect violence forcing the inner end of the clavicle in front of the sternum. The dislocation usually reduces itself spontaneously, but if this does not happen reduction is readily effected by traction on the abducted

arm. In the absence of treatment the joint remains unstable and re-dislocation or partial re-dislocation occurs with any vigorous movement of the arm. The resulting disability interferes seriously with many occupations.

TREATMENT. If the clavicle is replaced immediately after the accident and is kept in position for some weeks, the torn ligaments are repaired and a good result may be expected. The method of fixation is to place a pad of wool in the axilla, carry the elbow well in front of the body and fasten it there with adhesive plaster; a thick pad of felt is then placed over the inner end of the clavicle and held with another strip of plaster to maintain downward pressure. Fixation is necessary for about six weeks.

Conservative treatment is useless for old-standing dislocations. If the symptoms warrant it, operative repair can be successfully carried out by passing a suture of fascia lata through the clavicle and the back of the sternum. Some surgeons prefer to excise a length of the inner end of the clavicle.

## TUBERCULOUS DISEASE OF THE SHOULDER

The gleno-humeral joint is the least common of the large joints to be affected by tuberculous disease. Whitman gives the incidence in children as between one and two per cent of all cases of bone and joint tuberculosis. In adults involvement of the shoulder is relatively more frequent, but the total incidence is still small.

### Clinical Features

The disease usually commences in the head of the humerus and soon spreads to the joint cavity. Two types are recognized.

(*a*) A DRY FORM (*caries sicca*) in which there is gradual destruction of bone by caseous infiltration. Pus formation is minimal and therefore abscesses and sinuses are unusual. The joint is fixed by spasm, and atrophy of the muscles round the shoulder is extreme.

(*b*) A FORMATIVE TYPE in which there is extensive formation of pus which distends the joint and makes the shoulder appear broader. An abscess frequently tracks forwards to point in front of the deltoid, and sinuses, often multiple, are common.

The typical symptoms of tuberculous disease—pain, deformity and restriction of movement—are less obvious at the shoulder because it is not a weight-bearing joint and because loss of movement at the gleno-humeral joint is masked by scapulo-thoracic movement. Tuberculosis should be suspected whenever there is gradually increasing stiffness of the shoulder accompanied by gross muscular wasting.

The onset as a rule is extremely gradual but deterioration is steady and without remission. Weakness of the arm and stiffness of the shoulder are often the first complaints. The absence of pain is a striking feature; many patients have no pain throughout the whole course and suffer at most a dull ache which is somewhat aggravated by excessive use of the arm. Only occasionally is the pain severe and sleep at night interfered with.

*Examination* in the dry form shows gross muscular wasting. The hollow-

ness of the supraspinatus and infraspinatus fossæ is emphasized by the spine of the scapula projecting between them, and there is obvious flattening of the shoulder due to atrophy of the deltoid. Movement at the glenohumeral joint is reduced or absent, and there is tenderness over every aspect of the joint including the axillary surface. When there is much pus formation the abscess may obscure wasting of the deltoid, but not wasting spinati.



Fig. 237 Tuberculosis of the shoulder originating in the metaphysis of the humerus

**X-rays** (Fig. 237). The initial focus may be in the metaphysis or in the juxta-articular bone, but the infection soon invades the joint. The articular surfaces are destroyed and also a varying amount of the head of the humerus and the glenoid portion of the scapula. Sequestræ are common but there is seldom sclerosis or new bone formation. Decalcification of the neighbouring bone is usually extensive.

**Diagnosis.** Clinical diagnosis may be difficult, but a long history of disability with comparatively little pain, tenderness over the axillary surface of the joint, and extreme muscle wasting is very suggestive of tuberculous disease. An X-ray examination should always be included when investigating the cause of a stiff and painful shoulder.

### Treatment

The prognosis is fairly good provided there are no other tuberculous lesions but unfortunately associated pulmonary disease is common and [illegible]ment in an open-air hospital must be regarded as essential.

Local treatment consists in immobilization of the shoulder in the best position for ankylosis. A plaster spica is applied with the arm abducted in the scapula plane and in neutral rotation (Fig. 238). When possible the amount of abduction should be about 80° in young children, decreasing to 45° in middle age. A window is cut in the plaster to permit regular inspection of the joint.

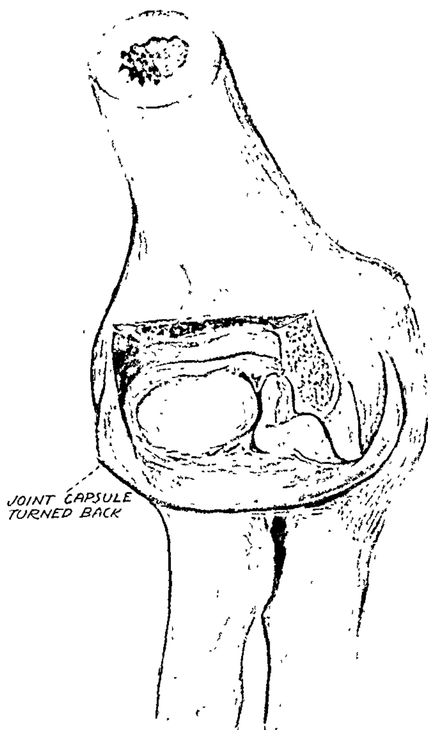


FIG 238 A shoulder likely to become ankylosed should be immobilised in such a position that the hand will touch the mouth An X-ray is necessary to check the scapulo-humeral angle

Healing is by fibrous ankylosis, or by bony ankylosis if there has been secondary infection. Sinuses may persist indefinitely, even when the disease appears to be quiescent.

Operation plays little part in the treatment of the active lesion, but when the disease is quiescent arthrodesis is usually desirable to give additional security. Arthrodesis should be performed by an extra-articular method; either the acromial process is bent downwards and its tip implanted into the greater tuberosity of the humerus, or Brittain's method may be used and a tibial graft introduced below the joint between the scapula and the humerus.

PLATE IV




The Left Elbow

Part of the lower end of the humerus has been removed to show the fold of the synovial membrane around the head of the radius

*To face page 305]*

## CHAPTER VIII

# THE ELBOW

## "TENNIS ELBOW"

This blunderbuss name is commonly applied to every disorder in which there is pain at the outer side of the elbow caused by energetic use of the arm. It resembles the term "low back pain" in that its use precludes any attempt to understand the pathology of the several lesions included. Only in a minority of patients is "tennis elbow" caused by playing tennis, and any occupation requiring a tight grip and rotary movements of the forearm may be responsible. It is certain that several distinct pathological conditions are included although they are not yet fully understood. The classification used here is only tentative but it is of help in prescribing treatment.

There are two main types of lesion—intra-articular which are usually of sudden onset, and extra-articular which often develop gradually.

### Intra-Articular Lesions

This type is the less common of the two but it includes a higher percentage caused by playing tennis. The pathology has been observed only during the later stages and the real nature of the process is a matter for conjecture, but the probability is that a fringe of synovial membrane is nipped between the articular surfaces of the radius and the humerus.

There is a delicate fringe of synovial membrane lying at the periphery of the radio-humeral joint, and usually quite a large tag posteriorly at the angle between the radius and the ulna (Plate IV). It seems that a filament of this fringe, as a rule the posterior tag, is displaced by an unguarded movement and becomes caught in the joint. Unless it is freed within a short time it becomes œdematous and eventually sloughs; a raw spot is left which may later adhere to another part of the synovial membrane forming an adhesion. The raw spot is only a few millimetres in diameter and looks very like a small urethral caruncle. The stages at which there is a raw spot or an adhesion have been observed at operation, but there is no positive evidence that the initial lesion is a nipped synovial fringe. It is only certain that there is some disorder of sudden onset which can often be relieved by manipulation and which, if neglected, develops the other changes described.

**Signs and Symptoms.** There is a history of pain coming on suddenly during the pursuit of a characteristic occupation. The pain rapidly becomes worse and interferes with the use of the arm, and it may radiate down the outer border and dorsum of forearm. It is relieved by rest, but it returns when the arm is used again.

On examination there is tenderness over the radio-humeral joint, usually posteriorly, and sometimes anteriorly (Fig. 239). Extension of the elbow and pronation are both slightly restricted and painful. Radiological examination is negative.

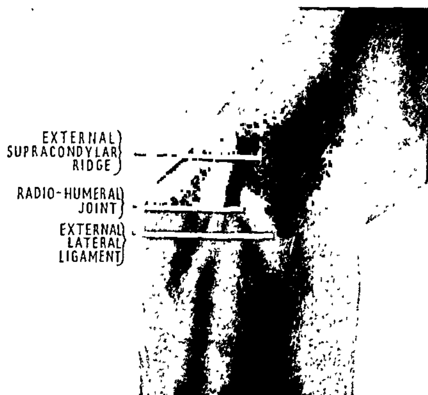



Fig 239 Outer side of right elbow to show the usual sites of tenderness in "tennis elbow"

**Treatment.** At an early stage before the nipped synovial fringe has degenerated manipulation is usually successful. If carried out immediately after the onset, the result may be dramatic and the pain is instantly relieved ; if, however, there has been time for an inflammatory reaction to develop in and around the fringe, it takes a few days for the symptoms to subside.

Manipulation may also be successful at a late stage after an adhesion has formed. During the intermediate stage there is a raw area in the joint which has to heal, and manipulation is contra-indicated. The elbow should then be strapped and rested. The strapping should be applied with the elbow slightly flexed, and stretch from the middle of the upper arm to just above the wrist. Short-wave diathermy assists in promoting resolution but massage and movements should be avoided. It is difficult to determine clinically the duration of this stage but it probably lasts for some weeks.

Manipulation during the early stage can be performed without an anæsthetic, but when adhesions are present an anæsthetic is desirable. The operator holds the elbow with one hand in such a way that his thumb rests on the back of the head of the radius ; with the other hand he holds the patient's hand and moves the arm into a position of slight flexion of the elbow, full pronation and full flexion of the wrist (Fig. 240). The manipula-

tive movement consists in extending the elbow whilst maintaining pronation and flexion of the wrist. The movement is made gently but quite sharply, and it is essential that the patient's muscles are relaxed. It causes no pain to a normal elbow but there is a sharp pain when a "tennis elbow" is freed. Another method of manipulation that is often successful is to open up the radio-humeral joint by adducting the elbow sharply.



FIG 240 Manipulating the radio-humeral joint

## Extra-Articular Lesions

Several different varieties are included in this group but there is not sufficient detailed knowledge of the pathology to separate them with certainty, and any of the following lesions of the ligaments, muscles or fascia may be present :—

1. Sprain of the lateral ligament of the elbow.
2. Sprain of the fibres of origin of the extensor muscles. The extensors of the wrist and fingers have a common tendon of origin which arises from the external supracondylar ridge of the humerus, from the lateral ligament, from the intermuscular septa between the extensors and the neighbouring muscles, and from the aponeurosis covering them.
3. Inflammation of the intermuscular fascia.
4. Inflammation of a small adventitious bursa between the external epicondyle and the common tendon of the extensors (Osgood).
5. An occasional lesion at the back of the elbow on the inner side of the olecranon, possibly in connection with the fibres of the triceps which are inserted into the capsule of the joint (the subanconeus).

**Signs and Symptoms.** There is a history of pain, usually of gradual onset, which the patient attributes to tennis or to an occupation involving much use of the forearm, such as clipping the garden hedge. The pain may not be noticed at the time but it comes on soon after, or perhaps next day. It is improved by rest and returns again on use ; excessive use may cause widespread aching in the muscles of the forearm, particularly if gripping tightly is involved.

On examination there is usually an area of acute tenderness than can be

localized accurately; the typical sites are over the lateral ligament, and over the common extensor origin either just above or just below the lateral epicondyle (Fig. 239). During the acute phase there is sometimes diffuse tenderness over the extensor muscles. There is a full or nearly full range of active and passive movements but pain is caused by extending the elbow. The pain is usually increased by pronating the forearm and flexing the wrist whilst the elbow is extended, and occasionally by supinating the forearm and extending the wrist. The X-rays are generally negative.

*Extra-articular lesions are distinguished from intra-articular by the* history of onset, the site of tenderness and the absence of limitation of extension of the elbow.

**Treatment.** Injuries of this type do not respond to active treatment as satisfactorily as most minor injuries and sprains, perhaps because the muscle fibres concerned are attached to ligaments and fascia. Some are very resistant, and even when they have nearly recovered, the symptoms return the first time the arm is used vigorously. There must be complete freedom from pain and tenderness before it is safe to recommence strenuous occupations.

The earlier treatment is begun, the better the prospect of rapid cure. The elbow should be firmly strapped and the strapping carried well down the forearm to limit the use of the muscles. All vigorous use of the hand, *especially gripping, must be avoided but the arm need not be kept in a* sling; the strapping should be renewed as often as is necessary to keep it tight. After about ten days exercises may be begun cautiously and they are progressively increased as long as there is no pain, for this is an indication that too much is being done. It is essential to wait until all pain and tenderness have gone before using the arm normally or the symptoms may return and the condition becomes chronic.

Recovery is very slow when treatment has been delayed and there is diffuse tenderness over the muscles of the forearm. The elbow should be strapped until the generalized pain and tenderness have subsided, and all movements causing pain must be avoided until there is complete recovery, even if this takes months. When the general inflammation has subsided, localized areas of tenderness may be treated by infiltration with novocain (p. 52), short-wave diathermy and massage. Manipulation is of value at a late stage if there are adhesions in the intermuscular planes. The indication for manipulation is restriction of movement accompanied by localized pain when movement is forced. Infiltration with novocain gives relief lasting for some hours and therefore a player can be enabled to play an important match by carrying out this procedure immediately before it.

Nearly all patients recover in the course of time, but occasionally symptoms persist indefinitely, or recur each time the arm is used. If the symptoms are sufficiently severe, and if they are restricted to a single localized area, operation may be justifiable. It should be carried out under local anæsthesia and without previous infiltration of the deep tissues; the tender area can then be identified with the help of the patient and excised.

## OSTEOARTHRITIS

This is not a very common cause of disability because the elbow is not a weight-bearing joint, and there can be a surprising amount of disorganization without serious pain. Symptoms arise chiefly in connection with the radio-humeral joint through which pressure on the hand is transmitted, but the radio-ulnar joint is sometimes affected, and occasionally the humero-ulnar joint. Periarticular ossification, which is so common after dislocation of the elbow and other major injuries, must not be mistaken for osteoarthritis.

Osteoarthritis of the elbow is usually caused by trauma, either a malunited or ununited fracture, or frequently repeated minor traumata. Workers with compressed air drills are particularly liable to develop severe osteoarthritis of the radio-humeral joint. It seems that the repeated jarring causes interference with the blood supply of the bone and leads to extensive necrosis and absorption; typical osteoarthritic changes are later superimposed.



Fig. 241 Osteoarthritis of the right elbow of the captain of a steam tug whose occupation required him to turn a small wheel very quickly

The symptoms are pain and limitation of movement. When the head of the radius is involved, rotation is the movement chiefly affected. Pain is not constant and usually is felt only at the extreme of the permitted range of movement; many patients are therefore able to remain at work, but some occupations may be impossible, especially those involving pressure on the hand or rotary movements. Locking of the joint due to the presence of a loose body is sometimes the first symptom to attract attention.

**Treatment.** Conservative. Heat and massage give some relief from

symptoms provided energetic use of the arm can be avoided. When the pain is severe it may be necessary to provide an appliance to restrict movement of the elbow. A plaster cast can be used as a temporary measure, but for permanent wear a moulded leather or plastic splint is more convenient ; the apparatus should extend from axilla to wrist, and if rotation has to be controlled the metacarpals must be included. An elbow hinge with a lock that will fix the joint at any desired angle is an added convenience (Fig. 242). No compressed air worker should continue at the same work after the first sign of trouble.

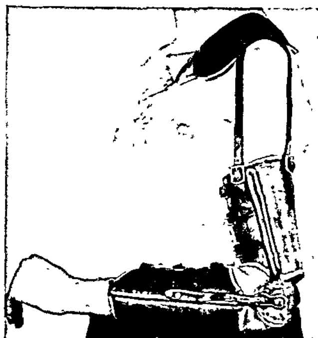


FIG 242 Elbow corset with hinge and lock

OPERATION is necessary (a) for the removal of loose bodies, and (b) when there is much pain and disability which cannot otherwise be controlled, especially in young people.

*Excision of the head of the radius* is of value when symptoms are restricted to the radio-humeral or radio-ulnar joints.

*Arthroplasty* gives a more or less painless joint with a range of movements about 50 per cent of normal, but both stability and power are considerably reduced ; the operation should only be performed when there is much pain and some movement is essential (p. 395).

*Arthrodesis* is a good procedure when the affection is unilateral unless it is of paramount importance to retain some movement. The best position for arthrodesis varies with the occupation of the patient. The standard position for the right arm is pronation 50 per cent and flexion about 100° to permit writing and the use of a table knife; and for the left arm the same amount of pronation but flexion of rather less than a right-angle to enable a fork to be put to the mouth.

## OSTEOCHONDRITIS DISSECANS

This condition is probably identical with osteochondritis dissecans of the knee. The elbow is affected more frequently than any other joint except the knee, but because it is often difficult to demonstrate radiologically, the incidence is usually underestimated.

The pathology is described in detail on p. 185. The typical sites to be affected in the elbow are the lower aspect of the capitellum of the humerus, and that part of the head of the radius which is in contact with the ulna



Fig 243 Osteochondritis dissecans of the capitellum of the humerus.

when the forearm is supinated. A small, circular area of articular cartilage together with a flake of the underlying bone separates from the rest of the bone and may become completely detached to form a loose body in the joint.

A condition occurring in workers with compressed air drills is sometimes called osteochondritis dissecans but it does not have the typical appearance of this affection and is better described as traumatic osteoarthritis.

Osteochondritis dissecans of the elbow may be seen at any age between twelve and twenty-five years but usually between fifteen and eighteen. The onset of symptoms is gradual and there is seldom a history of trauma. There is a moderate amount of pain, limitation of movement, and loss of power. Locking may occur when the fragment is completely detached. On examination there is tenderness over the affected site and often some swelling of the joint.

X-rays show the saucer-shaped line of demarcation of the separating fragment (Fig. 243). This may only be demonstrable when the affected site is seen in profile, and even then it may be partly obscured by the head of the radius.

**Treatment.** Osteochondritis of the capitellum of the humerus usually

recovers with rest. The arm is fixed in a light plaster-of-Paris cast with the elbow at a right-angle and the forearm in neutral rotation. Fixation is maintained until the X-rays show the fragment is becoming re-attached, probably three to six months. If there is no improvement during this time, or if the fragment becomes completely detached, it should be excised.

Disease of the head of the radius is said not to respond as readily to conservative treatment and therefore excision of the fragment is more frequently practised.

## LOOSE BODIES

Loose bodies in the elbow are common although they occur less frequently than in the knee; in the author's practice the proportion has been as one to two. A small loose body in the coronoid fossa is easily overlooked in radiographs unless stereoscopic films are available.



Fig 244 X-ray (printed in relief) showing two loose bodies in the front of the elbow joint

The pathology is in general similar to that of loose bodies in the knee (p. 184), but it is often difficult to determine the origin in a particular patient. Single loose bodies may be due to osteochondritis dissecans, which is commoner than is often supposed, to osteoarthritis, or to a detached fragment of articular cartilage. Multiple loose bodies may be due to synovial osteochondromatosis.

The onset of symptoms is often gradual. There is increasing stiffness of the joint, loss of power and a moderate amount of pain after use. True

locking and unlocking are more frequent when the loose body is situated posteriorly in the olecranon fossa than when it is in front of the joint; it can be tucked away comfortably in the coronoid fossa to be disturbed only at rare intervals.

**Treatment.** A loose body causing symptoms should be removed because an elbow liable to lock suddenly is a source of danger, especially to a motorist. Access to the whole of the front and the outer part of the back of the joint is given by an incision in the line of the lateral supracondylar ridge of the humerus. The inner part of the back of the joint may be approached through an incision along the inner border of the triceps.

## ULNAR PALSY

The ulnar nerve may be involved in injuries to the elbow either at the time of accident or soon after it (*primary palsy*), or after a long latent period (*delayed palsy*).

**Primary Ulnar Palsy.** This is uncommon. It is the result of contusion of the nerve (*neurapraxia*), and is usually associated with a fracture of the medial epicondyle of the humerus. On very rare occasions it is caused by compression of the nerve by callus. Spontaneous recovery is the rule.

**Delayed Ulnar Palsy.** Characteristically this develops a long time after injury, the latent period usually being at least ten years. As a rule the original injury is a fracture of the lateral-condyle of the humerus which has either failed to unite, or has united with gross upward displacement of the fragment (Fig. 245). In both instances there is valgus deformity of the elbow which lengthens the path of the nerve causing it to be stretched round the internal epicondyle. It seems that the strain on the nerve causes irritation of its sheath; the sheath responds by becoming thicker and the resulting fibrous tissue invades the substance of the nerve gradually strangling the nerve fibres. The reason for the long interval between the injury and the onset of symptoms is not understood but it has been noticed that symptoms often begin after unusually vigorous use of the elbow.



Fig 245 Ununited fracture sustained in childhood Ulnar palsy developed sixteen years later.

Similar pathological changes occasionally occur some years after an injury to the nerve, such as a blow, and without fracture or deformity of the elbow.

**Recurrent Dislocation.** Occasionally the ulnar nerve dislocates over the medial epicondyle during movement and the same pathological changes

occur. The onset of symptoms is insidious and the condition may exist for a considerable time without the patient being aware of it. The ætiology is usually unknown, but an injury is sometimes responsible.

## Signs and Symptoms

The first complaints are usually numbness and tingling over the inner border of the hand, pain at the inner side of the elbow on movement, and tenderness. Weakness and wasting of the small muscles of the hand supplied by the ulnar nerve develop slowly and progressively (i.e. the three muscles of the hypothenar eminence, all the interossei, the third and fourth lumbricals, the adductor pollicis and the deep portion of the flexor pollicis brevis).



FIG 246 Clawed hand due to ulnar palsy

The hand assumes the typical clawed appearance associated with paralysis of the interosseous muscles (p. 330), but the little finger and ring finger are affected to a greater extent than the others (Fig. 246). There may be anæsthesia of the little finger and the ulnar half of the ring finger. The nerve behind the medial epicondyle is usually very tender, and sometimes it is obviously thickened.

## Treatment

Conservative treatment is of little value and transposition of the ulnar nerve to the front of the elbow is the procedure of choice. This usually relieves pain and paræsthesiæ, and it may be followed by a return of sensation ; it also arrests the progress of muscle atrophy and deformity, but it does not cause improvement in existing wasting or deformity. Operation should, therefore, be performed early and before the muscles have wasted.

The nerve is exposed through an incision at the inner side of the elbow, lifted away from its position behind the internal epicondyle and deeply embedded in the substance of the flexor muscles. Care must be taken not to injure the motor branches to the flexor carpi ulnaris and flexor digitorum profondus which are exposed. After operation the arm is kept in a sling for a fortnight and then active use is commenced.

Severe clawing may be corrected by transplantation of the flexor sublimis digitorum of one of the fingers to replace the interossei (p. 330).

## TUBERCULOUS DISEASE

The elbow is the commonest site in the upper limb to be affected by tuberculous disease. The infection usually starts in the olecranon, and less frequently in the lower end of the humerus or the head of the radius. The disease frequently follows a slow and chronic course. The joint is involved early; it becomes distended with tuberculous material and the soft tissues around it are invaded. An abscess *often points on one or other side of the* olecranon, and sinuses, once formed, are very slow to heal.

The onset of symptoms is gradual but a sudden exacerbation may be caused by a minor injury such as a fall on to the hand, or by vigorous use of the arm. The first complaint is usually of pain and stiffness, but some-

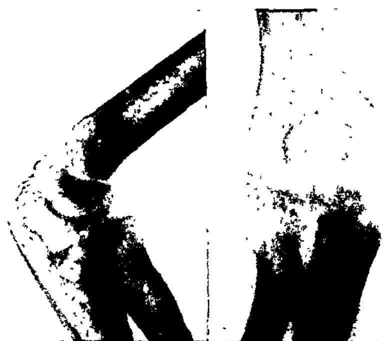


Fig. 247 Tuberculous disease of the elbow.

times swelling or even tenderness are noticed earlier. Pain, except in association with forced movement, is not a prominent feature.

On examination at an early stage there may be only slight limitation of movement, some muscle spasm, and possibly tenderness over the primary bony focus, usually the olecranon. Later, swelling becomes noticeable and movement is increasingly restricted. The swelling is most obvious posteriorly on each side of the olecranon, and the joint stands out in marked contrast to the wasting of the surrounding muscles.

X-rays show the characteristic appearance of tuberculous disease. There is loss of outline of the joint, destruction of bone and general decrease in density of the bones forming the joint. In adults a small abscess cavity in the olecranon is often the most obvious radiological change (Fig. 247).

**Treatment.** Conservative treatment in both children and adults gives a high percentage of successful results, but it is important for it to be

carried out in an open-air hospital until the general condition is satisfactory and it is certain that there is no active pulmonary disease.

Local treatment consists in fixating the joint in the best functional position (p. 310). A plaster-of-Paris or perspex cast extending from the axilla to the metacarpals is usually sufficient but a spica including the chest and shoulders may occasionally be desirable. Healing is by fibrous ankylosis and fixation should be continued for a considerable time after the disease is apparently quiescent.

Operation is seldom required. In adults, when the infection appears to be limited to an extra-articular focus in the olecranon, it is tempting to excise the focus, but the disease is usually more wide-spread than is expected, and the formation of a sinus in the scar is only too common a sequel. Occasionally, when there is an unsatisfactory response to conservative treatment, or when there are persistent sinuses, excision of the joint is indicated.

CHAPTER IX

# THE WRIST AND HAND

## TENDONS AND TENDON SHEATHS

### Tenosynovitis

ACUTE non-suppurative tenosynovitis is an apparently trivial condition but it has become common in these days of competitive production and is responsible for the loss of a considerable amount of working time. The tendons of the hand are affected more often than those of the foot, and the flexors more than the extensors. The pathological appearance has occasionally been seen at operation : the tendon sheath, which should be smooth and glistening, contains small hæmorrhages, and the inner surface of the sheath is rough and red over a considerable area.

There are four known causes :—

1. *Trauma,* such as a blow over a tendon. There is immediate pain which gets worse during the next few days.

2. *Strain* due to overstretching may rupture a few fibres of the tendon.

3. *Repeated Rapid Movements,* usually those requiring pressure, as when squeezing a grip. It is possible that an unnoticed contusion is responsible for determining the onset.

4. *Benign Tumours.* Sometimes a ganglion presses on a tendon and interferes with its free movement, and on rare occasions the cause is a small fibroma or a synovioma.

The chief symptom is pain which is felt in the region of the affected tendon and radiates widely over the forearm and hand. It is made worse by movement and may be most disabling. On examination, there is tenderness on pressure over the tendon, and there is often crepitation which can be felt and also heard on auscultation. Sometimes there is swelling in the line of the tendon.

**Treatment.** Recovery takes place fairly quickly, usually within about three weeks, when the hand is rested. A plaster-of-Paris splint extending from elbow to fingertips is applied with the fingers in the position of rest (Fig. 269, p. 374). The splint is removed once daily for short-wave diathermy, and gentle passive movements are given to prevent stiffness; it is worn until the tenderness has disappeared, and work involving the use of the hand should be avoided until all pain has gone, or the symptoms may recur. When rapid recovery is less important than continued use of the hand, some relief can be given by strapping the forearm and hand with an elastic bandage.

## Ganglion

A ganglion is a cystic swelling occurring in association with a joint or tendon sheath. It has a fibrous outer coat, an inner synovial layer closely resembling the synovial membrane of a joint, and it contains thick, gelatinous fluid.

The ætiology of ganglia is still uncertain and no really satisfactory theory has yet been advanced. Some pathologists regard them as herniations of tendon sheaths or joints, but others consider them to be neoplasms developing from embryonic rests in the peri-articular connective tissue, or as resulting from cystic degeneration of the same tissue. There is a close relationship between ganglia and bursæ and it is often impossible to draw a distinct dividing line between them.

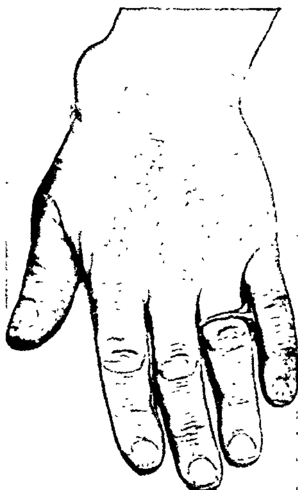


FIG 248 Ganglion

Ganglia occur most frequently around the wrist and hand, and the ankle and foot. They are at least five times more common on the dorsal surface than on the ventral. As a rule they grow slowly, although sometimes they appear quite suddenly. The chief symptom is swelling (Fig. 248) but there may be some weakness of the grip and aching of the hand, and occasionally there is pain from pressure on adjacent tendons or nerves.

Differential diagnosis has to be made from epidermoid and mucous cysts, lipomata, neuromata, synoviomata, etc. A tense, spherical ganglion often found near the palmar surface of one of the metacarpo-phalangeal joints is frequently described after clinical examination as an exostosis.

**Treatment.** Spontaneous disappearance without treatment is not uncommon. The simplest treatment is to burst the ganglion by firm digital pressure and disperse the fluid into the surrounding tissues. If it cannot be burst, it can be perforated by multiple punctures made with a needle and then dispersed by pressure. Recurrence is common but many ganglia eventually disappear after being burst or punctured a number of times.

Large ganglia, and those which recur continually, require excision. The operation should be performed in a bloodless field and the surgeon must be prepared for an extensive dissection amongst the tendons. Recurrence is unusual provided the entire structure is removed with meticulous care.

Aspiration and injection of a sclerosing fluid is sometimes recommended but it is not uniformly successful; it is not without risk and often has to be repeated several times. Radiotherapy is credited with many successes.

## Tendon Sheath Tumours

(*Synonym*) Synovioma

Tumours derived from the synovial layer of tendon sheaths occur both at the wrist and ankle, but more frequently at the wrist, and also in connection with joints. Most of them are benign, a certain number are frankly malignant, and there are many transitional types. They are either pedunculated, when they are always benign; or they spread diffusely over a considerable length of the sheath when they are often, but not invariably, malignant.

The intimate structure of synovial tumours varies considerably and at one time they were named after the predominating cell, for example lipoma, xanthoma, endothelioma, and chondroma. King has pointed out, however, that the basic cell is always of synovial origin, the secondary cells being derived either directly from the adjoining tissues, or by transition of the synovial cells to cartilage, bone, etc. He considers that nothing is gained by identifying the tumour with these secondary cells.

In benign tumours the typical cells are spindle-shaped cells rather like fibroblasts, and the nuclei show but few mitotic figures. There are usually many large spheroidal cells which may contain droplets of fat (*foam cells*), and often they are multinucleate (*giant cells*). The presence of giant cells, which are of the ordinary foreign body variety, and of foam cells, which are produced by ingested cholesterol, fatty debris, etc., is not essential to the diagnosis. Malignant tumours have a similar composition but the cells are irregular, the cell boundaries are poorly defined and there are many mitotic figures. A characteristic feature of both benign and malignant tumours is the presence within the tumour of spaces lined with synovial cells.

Synoviomata usually occur during early middle age. They grow very slowly and cause symptoms chiefly by their size. The pedunculated

variety may interfere with the movement of a single tendon or a group of tendons. Diffuse tumours grow to a considerable size and are readily mistaken for lipomata, especially when occurring at the ankle. They cause pain and aching on use of the limb, restriction of movement, and ultimately there may be considerable disability.

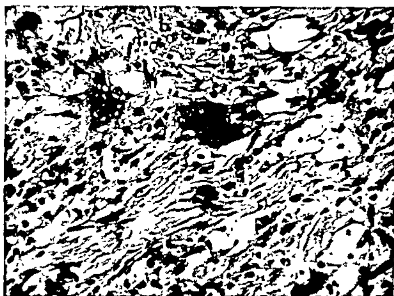


FIG 249 Microphotograph of a synovioma (by courtesy of Prof R W Scarff)

**Treatment.** Pedunculated tumours should be excised together with the portion of the tendon sheath from which they originate. Diffuse tumours also require excision and every fragment must be removed or local recurrence is certain. Excision is often extremely difficult, particularly at the ankle, because of extensive spread along the tendons passing into the sole of the foot and up the calf. Frankly malignant tumours metastasize via the lymphatic system and amputation is often recommended; there is little evidence, however, that life is thereby prolonged and it may be wiser to retain the limb for as long as it remains useful.

## Stenosing Tenovaginitis

(*Synonyms*) de Quervain's disease, Hoffman's disease

This is a common complaint which has received but scant attention in text books although accounts of it were first published in the last century. The essential feature is thickening of the common sheath of the abductor pollicis longus and extensor pollicis brevis tendons where they lie on the outer side of the lower end of the radius. The thickening is fusiform in shape and 2 to 3 cms. long. Its greatest thickness is usually between 2 mm. and 3 mm., but in an extreme example it may be as much as 5 mm. Sometimes, although typical symptoms are present, there is only a trivial amount of thickening.

The condition is more frequently seen in women than in men. The ætiology is unknown but it has been suggested that trauma is a factor because the complaint is often seen in people whose occupation involves

strong gripping by the partly abducted thumb, for example, wringing the household washing. It frequently occurs, however, in those following more gentle pursuits when no such causal factor can be found.

The onset of symptoms is usually gradual. There is pain felt at the outer side of the wrist and radiating up the forearm and down the thumb. The pain is aggravated by the use of the hand and it gradually gets worse until ultimately it may cause considerable disability. Occasionally the onset of pain is abrupt and follows a minor strain or injury.

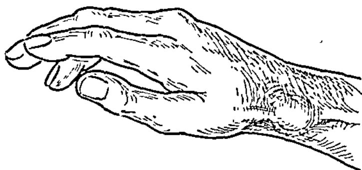


FIG 250 Stenosing tenovaginitis

On examination, there is often a visible swelling on the outer side of the lower end of the radius (Fig. 250). There is tenderness on pressure, pain on active abduction of the thumb, and pain on forcing the hand into ulnar adduction whilst the wrist is flexed and the thumb opposed.

**Treatment.** Some amelioration of symptoms follows conservative treatment such as rest with the wrist fixed in a plaster-cast, but the pain returns when free use of the hand is re-commenced. Many patients have been treated conservatively for years without permanent relief, the diagnosis varying from arthritis to neuritis, and it is doubtful if recovery ever takes place without operation.

Operation is regularly followed by immediate relief from symptoms, and it should be advised whether or not there is palpable thickening of the tendon sheath. It is a simple procedure consisting only in making a longitudinal incision through the thickened portion of the sheath. When the sheath is greatly thickened a segment may be excised, but this is not often necessary. Active movements are commenced the day after operation and the patient can return to work in a few days.

## Trigger Finger

This is an affection in which free movement of the flexor tendons of one of the fingers or of the thumb is prevented by narrowing of the tendon sheath. It may occur at any age but chiefly in infancy and during middle life. The thumb is most frequently affected in infancy, and the middle finger or forefinger in adults. As a rule only one finger is affected but sometimes several fingers in both hands are involved.

The lesion, which is almost always at the level of the metacarpophalangeal joint, consists in (*a*) a stricture of the tendon sheath, and (*b*) a small nodule in the tendon distal to the stricture. As a rule the sheath

is thickened in a manner closely resembling de Quervain's stenosing tenovaginitis, but sometimes there is only a local constriction of the sheath and no general thickening, The nodule forms within the tendon, usually the profundus, as the result of it being "bunched up" by the milking action of the stricture.

The affected finger can be flexed actively but whilst doing so a snap is felt as the nodule in the tendon passes through the stricture, and a similar snap occurs during extension. Active extension is often impossible and the finger can only be straightened with the assistance of the other hand; sometimes it cannot be straightened at all. On palpation over the metacarpo-phalangeal joint, the nodule can be felt to move during active flexion and extension of the finger.

**Treatment.** The treatment, which can be carried out at any age, consists in division of the stricture of the tendon sheath. This is followed by immediate and permanent relief. The incision through the skin should be transverse but the sheath is incised longitudinally on one of its lateral aspects, not centrally.

## Rupture of Tendons

Two tendons of the hand are liable to rupture spontaneously, or from trivial violence—the extensor pollicis longus and the extensor digitorum. The latter, when it gives way at the terminal interphalangeal joint, causes a "mallet finger," and when it ruptures at the proximal interphalangeal joint, it gives rise to a "button-hole deformity."

**Extensor Pollicis Longus.** "Spontaneous" rupture of the tendon of this muscle takes place where it lies in a groove on the back of the lower end of the radius. It often follows an injury to the bone at this site, as a rule after a latent period of several months, but it also occurs in old-standing rheumatoid arthritis. It is unusual after the typical comminuted Colles fracture and is more often seen after a transverse fracture passing across the back of the radius. When rupture appears to follow a sprain of the wrist, radiological examination usually shows evidence of an old fracture. The tendon at the site of the fracture becomes frayed and attenuated, although why this should happen is not clear, and it is ruptured by some trifling violence. When the cause is rheumatoid arthritis the patient may not be aware of what has happened until he consults his doctor because of awkwardness in using the thumb.

The signs of the lesion are inability to extend the thumb actively at the interphalangeal joint, and absence of the tendon from its prominent position on the ulnar side of the "anatomical snuff box."

TREATMENT. Operation is desirable in younger people, but it is not necessary when the hands are already crippled by arthritis. End to end suture of the ruptured tendon is unsuccessful because of its attenuated condition and repair should be effected either by excising the pathological portion of the tendon and introducing a free graft, or else by suturing the distal end to the extensor pollicis brevis. Both methods give excellent functional results.

**Mallet Finger.** This deformity is caused by :—

(*a*) Avulsion of the extensor tendon from its insertion into the base of the terminal phalanx either with or *without an attached fragment* of bone. It is usually due to a blow on the tip of the finger flexing it forcibly at a moment when the extensor tendon is contracting, as when extending the hand to catch a ball (Fig. 251).

(*b*) Rupture of the tendon immediately proximal to its insertion. This is caused by inco-ordinated contraction of the muscles and may follow much smaller violence, or occur without any injury at all, as when a woman slips her hand into a silk stocking preparatory to putting it on.



Fig 251 Mallet finger with avulsion of a fragment of the distal phalanx



Fig 252 Position of immobilization of mallet finger

The finger is held with about 70° of flexion at the terminal interphalangeal joint, and after a time the proximal interphalangeal joint becomes hyperextended. The terminal joint cannot be extended actively but there is normal passive movement. The flexed terminal phalanx is of considerable inconvenience, and even when it does not interfere with work, it causes constant annoyance by catching in the trouser's pocket or handbag.

Treatment by fixation of the finger in plaster-of-Paris gives an excellent result provided this is done early and the plaster is applied correctly. The terminal joint is extended to bring the fragments into contact, and the proximal joint is flexed 90° to relax the lateral slips of the tendon. The plaster is not difficult to apply if the patient is first taught to hold the finger in this position himself, and then he can be responsible for its position whilst the plaster dries (Fig. 252).

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# SPRAIN

## The Wrist

Sprain of the wrist is an uncommon accident, and when there appears to be a sprain it is usual to find that there is really a fracture, a dislocation or arthritis. X-rays in several planes, preferably stereoscopic, should always be taken when the wrist is injured. Fracture of the scaphoid is readily overlooked in films taken immediately after injury, and if pain and tenderness persist for a fortnight, further radiological examination should be made; the fracture seldom unites if left untreated, and although the symptoms may subside temporarily, osteoarthritic changes occur later. Avulsion fracture of a flake of bone from the dorsum of one of the carpals is caused by a fall on the back of the hand when the wrist is palmar flexed; This should be suspected if there is tenderness over the dorsum of the carpus, and confirmation may be obtained by X-rays taken in a tangential plane.

Osteoarthritis of the radio-carpal joint often remains symptomless for a long time, especially when caused by an ununited fracture of the scaphoid. The onset of symptoms may be precipitated by injury and then the existence of both the arthritis and the fracture are revealed radiologically. Immobilization of the wrist in plaster-of-Paris for a month often relieves the pain and restores the wrist to the condition it was in before the accident. It is unwise to treat the fracture, particularly by operation, unless there is serious disability (p. 331).

## Metacarpo-phalangeal Joints

Sprains occur from forcible lateral angulation or hyperextension. There is considerable swelling, pain and disability and, like sprains of the interphalangeal joints, recovery is slow. Recent injuries, when severe, should be immobilized for two to four weeks with the hand in the position of rest (Fig. 269, p. 344).

Rupture of the external lateral ligament of the thumb may be very troublesome. The thumb is unstable and weak, and on examination there is unnatural mobility. A complete rupture, if recent, unites with fixation in a plaster cast for a month, but an old injury may require repairing with a fascial graft.

## Interphalangeal Joints

The delicate capsule and lateral ligaments of these slender joints are readily sprained or ruptured. When the joint is dislocated, as not infrequently happens, the ligaments are either torn across or a fragment of bone is avulsed. Forced hyperextension ruptures the anterior aspect of the capsule and this may cause an intractible flexion contracture when it heals.

These injuries are more serious than is generally admitted, even when the ligaments are only sprained. They are often left untreated and the finger remains crippled for many months (Fig. 254). The best procedure, immediately after injury, is to splint the finger in the position of rest for

The finger must be immobilized for four to six weeks. When the plaster is first removed the full range of active extension is not immediately present but it gradually returns during the next few months and the end result is usually perfect.

Old injuries are not satisfactorily treated by conservative methods but a good result can be obtained by re-attaching the tendon with a removable wire suture. Care must be taken not to injure the nail bed, which extends almost to the joint, or there will be permanent deformity of the nail.

**"Button Hole Deformity."** This deformity is not caused by a longitudinal split in the extensor tendon, as is often suggested, but by rupture of the central slip of the tendon at the level of the proximal interphalangeal joint. It occasionally occurs as the result of violence, but more often from a cut with a knife (Fig. 253).



Fig 253 Button hole deformity The little finger was amputated for an injury sustained at the same time

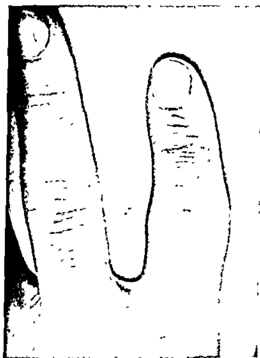


Fig 254 Sprain of the proximal interphalangeal joint of the left forefinger

The extensor tendon divides into three slips as it approaches the proximal interphalangeal joint. The central slip is inserted into the middle phalanx and the lateral ones join together and pass to the terminal phalanx. When the central slip is divided, the lateral slips are displaced towards the palmar surface and flex the proximal interphalangeal joint ; the terminal joint and the metacarpo-phalangeal joint are extended.

Treatment. Operation gives a good result, provided it is performed early, the central slip of the tendon being re-attached by a removable wire suture. With old-standing injuries, it is desirable also to join the lateral slips together over the dorsum of the joint with a similar suture.

family. Trauma is sometimes blamed and there is often a history of a single injury, or of frequently repeated minor injuries of an occupational nature.

**Clinical Features.** The condition occurs chiefly in middle-aged and elderly people, and occasionally in younger adults. Men are affected more frequently than women, and the right hand more often than the left, but sometimes it is bilateral. The ring finger is nearly always involved, and then the little finger, middle finger and forefinger in that order of frequency.

The first sign is a nodule which appears in the skin of the palm of the hand, or sometimes the first phalanx of the ring finger. The nodule increases gradually in size, other nodules appear and the skin becomes puckered (Fig. 255). The contracting fascia flexes the affected finger or fingers slowly and inexorably until, in an extreme case, the tips are pressed against the palm. The rate at which the deformity developes varies greatly and it may be a matter of months or of years before it is severe.

Examination shows the skin to be thick and nodular and adherent to the deep fascia. The affected fingers are flexed at metacarpo-phalangeal and proximal interphalangeal joints, and extended at the terminal interphalangeal joints. Attempts to straighten the fingers make the palmar fascia more tense.

**Treatment.** A slight deformity is comparatively easily corrected by operation and it may be sufficient to introduce a tenotomy knife beneath the skin and divide the contracted fascia in a number of places. With more severe deformities the whole of the affected fascia should be excised. This operation is performed through transverse incisions in the creases of the palm, and when separating the skin from the thickened fascia, care is necessary to avoid cutting through the deeper layers of the skin and devitalizing it so that it sloughs. Since the skin is contracted and without its usual elasticity, there is often insufficient to cover the finger after it has been straightened and then a skin-graft is necessary. Recurrence is unusual, at any rate for a long time, provided the dissection is sufficiently extensive.

## ISCHÆMIC CONTRACTURE

(*Synonym*) Volkmann's Contracture

Temporary arterial occlusion in any limb, at any level and from any cause may produce irreversible changes in the muscles, which die and subsequently are replaced by fibrous tissue. Volkmann originally postulated that the syndrome was caused by interruption of the arterial blood supply, but later it was attributed to venous occlusion. Recent experience, which is based on the operative findings of many surgeons, makes it clear that the old view is correct. A main arterial trunk is obstructed and this reduces the blood supply sufficiently to cause death of a few or many muscle fibres; the limited collateral circulation is sufficient to maintain the vitality of other structures.

The brachial artery is affected more often than any other, and the upper limb more than the lower. The commonest cause is injury, but

three weeks; even then, although function returns to normal, some fusiform swelling of the joint may remain permanently (Fig. 254). With oldstanding injuries, and many patients do not consult a doctor for some months, little can be done to speed recovery, but an assurance can be given that the pain will ultimately disappear, although some swelling may remain. Operation is necessary only in the exceptional instance when there is gross deformity.

## DUPUYTREN'S CONTRACTURE

The palmar fascia lies immediately beneath the skin of the palm of the hand. The proximal border is attached to the transverse carpal ligament and receives the insertion of the palmaris longus muscle; distally it terminates in four bands of which some fibres are inserted into the skin just proximal to the webs of the fingers, and some pass to the four inner digits. It is joined to the deep fascia of the palm by longitudinal septa.

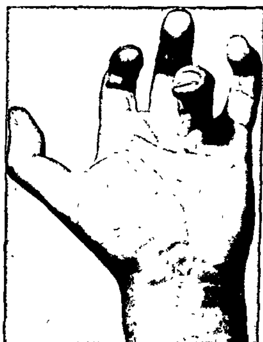


FIG 255 Dupuytren's contracture

In Dupuytren's contracture the palmar fascia is thickened and contracted, and one or more fingers are drawn into a position of flexion. The chief histological feature is fibroblastic proliferation; in some areas this proceeds very rapidly and the nuclei of many of the dividing cells contain mitotic figures. The fatty layers covering both surfaces of the fascia are infiltrated with fibrous tissue, and all the layers of the skin hypertrophy. *The changes are not spread evenly over the hand but affect* principally the ulna side.

The ætiology is uncertain but heredity may be a factor because the contracture has often been observed in several generations of the same





FIG 256 Ischæmic contracture

*Above* The wrist can be extended when the interphalangeal joints are flexed

*Below* When the interphalangeal joints are extended, the wrist flexes

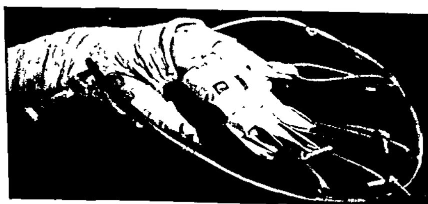


FIG 257 Extension for ischæmic contracture

ischæmic contracture can also follow thrombosis, embolism, or anything else obstructing the blood supply of the muscles, for example a rubber tourniquet. The injury may consist in a contusion or a laceration of the wall of the artery, or complete division of the vessel. The less severe injuries cause reflex spasm of a length of the artery and are perhaps more dangerous than complete division. A tight plaster encircling the limb is unlikely to be the sole cause of ischæmic contracture, as was thought at one time, but it may impede the collateral circulation and thus be a contributory factor.

**Clinical Features.** Acute Phase. The first symptom is usually a burning pain commencing within a few hours of injury, but the onset of pain may be delayed for a day or two. When the forearm is affected, the fingers are held partly flexed and pain is caused by passive extension; there is cyanosis and swelling of the fingers, the radial pulse is absent, and the skin temperature is reduced.

Chronic Phase. The dead muscle fibres are replaced by fibrous tissue which contracts and reduces the overall length of the muscle. The extent of the permanent damage depends on the amount of muscle destroyed; it may be slight and cause little impairment of function, or it may be great and a severe contracture results. In a typical example affecting the flexors of the hand and wrist, the fingers can be straightened only whilst the wrist is flexed, but when the wrist is straightened, the fingers are flexed (Fig. 256). Some power of active flexion of the fingers usually remains but it has little functional value because the wrist is flexed.

**Treatment.** Acute Phase. All possible steps must at once be taken to restore the circulation of the limb. Every source of pressure is removed, and the blood pressure and hæmoglobin content of the blood must be maintained, if necessary by blood transfusion. The limb is placed at rest in the horizontal plane, and it is kept cool whilst the remainder of the body is warmed. The fracture, if any, is reduced. Morphia is given for pain, and when there is a wound, penicillin or sulphathiazole are administered to reduce the risk of infection.

Exploration of the artery is indicated in many recent cases, that is those of less than twenty-four hours duration. An arteriogram is helpful in localizing the arterial lesion and in making the decision to operate. If a contusion is found, a portion of the vessel is resected; this often releases the spasm at once and enables a good collateral circulation to be established. Laceration or complete division of the artery may be treated by trimming and end to end suture. Spasm with no sign of arterial injury is sometimes relieved by novocain block of the cervical sympathetic, and it is advantageous for operations for this condition to be performed under regional anæsthesia using a brachial plexus block.

Established Contracture. Contracture can to some extent be prevented, and mild and moderate contractures can be improved, by continuous traction. Extension should therefore be applied as soon as it is certain that there is muscle damage, and it should be maintained for several months. A usual method of exerting traction is shown in Fig. 257;

from its insertion into the middle phalanx of one finger, withdrawn into the palm, split longitudinally into two portions, re-routed along the lumbrical canals to two adjacent fingers and attached to the sides of the extensor expansions at the site of the insertion of the interossei.

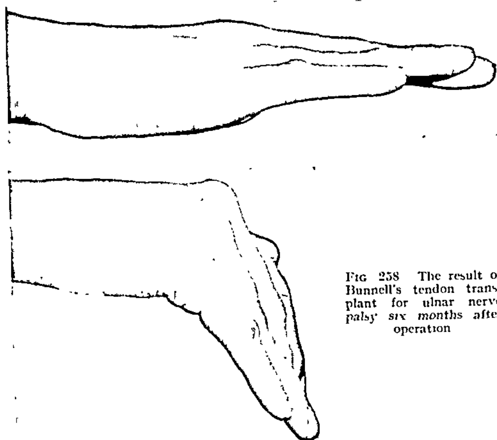


FIG 258 The result of Bunnell's tendon transplant for ulnar nerve palsy six months after operation

## OSTEOARTHRITIS

### *Radio-Carpal Joint*

Osteoarthritis of the radio-carpal joint is common because of the frequency with which the joint surfaces are injured, but the mid-carpal and other joints of the wrist are less often affected. The commonest cause of radio-carpal osteoarthritis is an ununited fracture of the scaphoid; fracture of the lower end of the radius, even when the articular surface is involved, is less frequently followed by arthritis, but the reason for this is not known.

The symptoms are pain on using the wrist, limitation of movement and tenderness. The pain may be severe, interfering greatly with active use of the hand and preventing all but the lightest occupations.

The earliest radiological change is often an appearance of sharpness of the articular margin of the radius, and the styloid process is prolonged and pointed. Later, the joint space is narrowed and there are changes in the trabecular structure of the affected bones. Although there is often some proliferation at the margins of the joint, there is seldom sufficient new bone to be dignified by the term osteophyte (Fig. 260).

the direction of the pull is such as just tends to extend the metacarpo-phalangeal joints. Traction is removed for a short time each day for active exercises.

Very severe contractures of the fingers, wrist and elbow, and fixed pronation of the forearm, are difficult to treat surgically. Many operations have been described, the most useful being *Max Pages's* muscle slide in which the common origin of the flexor muscles is detached and moved distally, and *Garré's operation* of shortening the radius and ulna thus increasing the relative length of the muscles.

## CLAW HAND

Claw hand is a familiar deformity which is caused by paralysis of the interosseous and lumbrical muscles. The action of these muscles is to extend the interphalangeal joints and flex the metacarpo-phalangeal joints; when they are paralysed these movements are impossible and the fingers are drawn by the unopposed action of the long flexors and extensors into a position in which the interphalangeal joints are flexed and the metacarpo-phalangeal joints extended (Fig. 246, p. 314).

Wasting of the small muscles of the hand occurs in a formidable number of conditions of which examples are given below.

| | |
|---|---|
| *Spinal Cord.* | Anterior poliomyelitis. |
| | Progressive muscular atrophy. |
| | Amyotrophic lateral sclerosis. |
| *Nerve Roots.* | Intervertebral disc prolapse. |
| | Leptomeningitis. |
| *Brachial Plexus.* | Obstetrical palsy. |
| | Pressure at the cervico-brachial junction. |
| *Median and Ulnar Nerves.* | Local lesions. |
| | Polyneuritis. |
| *Muscles.* | Dystrophies. |
| | Ischæmic contracture. |

Local lesions of the ulnar nerve, which is rather exposed to cutting and perforating injuries, are amongst the commonest causes of claw hand. The ulnar nerve supplies the following muscles: the ulnar side of the flexor digitorum profondus, the abductor, opponens and short flexor of the little finger, all the interossei, the lumbricals of the ring and little fingers, the adductor pollicis and part of the flexor pollicis brevis. In ulnar nerve lesions, clawing is greatest in the little finger and rather less in the ring finger; the forefinger and middle finger are only slightly affected because the lumbricals, which are usually supplied by the median nerve, are strong enough to prevent gross deformity. Hyperextension is most marked in the little finger because the deep flexor is involved as well as the interossei and lumbricals.

A clawed hand causes considerable inconvenience and is rather unsightly, but *Bunnell's operation* gives an excellent functional and cosmetic result (Fig. 258). *The tendon of the flexor sublimis muscle is detached*





FIG. 260 Osteoarthritis of the wrist following fracture of the scaphoid.
*Left:* Early changes two years after injury.
*Right.* Gross disorganization of the joint twelve years after injury.



FIG 261 Radio-ulnar dislocation resulting from a Colles's fracture



FIG 262 Osteoarthritis of the carpo-metacarpal joint of the thumb

**Treatment.** The wrist is only painful when it is moved, therefore some relief is given by wearing a splint. Permanent splints are made of moulded leather or a plastic and should hold the wrist in about 30° of dorsiflexion. Few patients are prepared to wear a splint indefinitely and operation is usually preferred. There are two types of operation, arthroplasty and arthrodesis.

ARTHROPLASTY consists in excision of the scaphoid and lunate bones. Some surgeons claim good results, but in my experience the wrist remains weak and rather painful. The operation may be indicated occasionally when movement is of paramount importance. Excision of one fragment of a fractured scaphoid does not improve the condition.

ARTHRODESIS is a sure method of relieving pain; although it makes the wrist stiff, the grip remains good and almost any occupation can be followed, including that of heavy labourer. It is also of value for the painful wrist of rheumatoid arthritis.

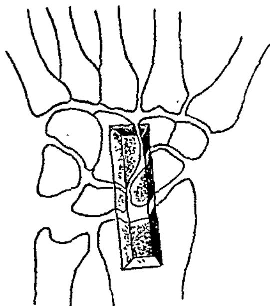


FIG 259 Arthrodesis of the wrist

A simple and satisfactory method of securing arthrodesis is as follows —a slot half an inch wide is cut in the carpus and lower end of the radius (Fig. 259), and part of the articular cartilage is removed from the joints between the radius, scaphoid, lunate and capitate bones; a graft with the appropriate curve is cut from the outer table of the ilium to fit the slot, and the spaces between the carpal bones are packed with cancellous bone. Fusion is rapid; the splints can be removed in six to eight weeks, and full work resumed after three months.

## Radio-Ulnar Joint

Disturbance of this joint is usually due to malunion of a fracture of the lower end of the radius. In a severe comminuted Colles's fracture the lower end of the radius is driven proximally thus dislocating the radio-ulnar joint, and unless the fracture is properly reduced the distorted joint may become a source of pain (Fig. 261).

The symptoms, which are not proportionate to the amount of distortion of the joint, are pain on pronation and supination of the forearm, tenderness on pressure over the radio-ulnar joint, and pain on passive antero-posterior movement of the joint.

**Treatment.** Excision of the head of the ulna is a satisfactory procedure which does not seriously interfere with the stability of the wrist. When this operation fails to relieve the pain it is usually because the source of the pain has been incorrectly determined.

crack fractures radiating through the spongy portion, and which may be caused by the lunate impinging on the corner of the radius.



FIG 264. Kienboch's disease in a sheet metal worker aged 29 years.

**Clinical Features.** The condition is one of early adult life and rarely occurs before the age of fifteen years. Men are affected more frequently than women, and the right hand more often than the left.

Four stages can be distinguished :—

1. *Onset*, often following a known injury, with pain lasting for a week or two.
2. *A Period of Remission* for some months.
3. *Active Disease* with symptoms continuing for some years.
4. *Osteoarthritis* and permanent pain.

The pain is not severe at first but the wrist aches, especially during and after use. It becomes gradually more troublesome over a period of time and interferes with manual work. There is tenderness over the lunate, and pressure over the distal end of the third metacarpal causes pain.

X-RAYS (Fig. 264). There may be symptoms before there is radiological evidence of disease. The first change is the appearance of patchy areas of rarefaction and increased density, and later the bone alters in shape becoming thinner and broader, and often wedge-shaped. Areas of increased density may persist for several years.

**Treatment.** The usual practice is to place the bone at rest until the structure has returned to normal. The wrist is fixed in dorsiflexion in a plaster cast and immobilization has usually to be continued for many months. When treatment is commenced early, resolution may take place without great alteration in the shape of the bone ; but when it is delayed, and this is usually the case, the bone is considerably distorted and osteoarthritic changes at the wrist joint are a common sequel. Treatment is then as for osteoarthritis (p. 332).

Excision of the lunate bone is sometimes practised when there is longstanding pain, but few surgeons claim successful results. Arthrodesis is the only certain method of giving relief and restoring working capacity.

### Carpo-Metacarpal Joint of the Thumb

*Osteoarthritis of this joint is a disabling cause* of pain which seriously interferes with the use of the thumb, and therefore of the whole hand (Fig. 262). It may be caused by a malunited Bennett's fracture dislocation, or by repeated minor traumata sustained at work, but often no cause can be found.

**Treatment.** A splint which restricts movement of the thumb is necessarily cumbersome and although it reduces the pain it is not always tolerated. Arthroplasty of the carpo-metacarpal joint may be performed either by re-shaping the bones, or by excising the trapezium, and on the whole the results are good. Arthrodesis with the first metacarpal in a partly opposed position is occasionally necessary; this is effected by removing the articular cartilage from the joint and grafting a block of bone between first and second metacarpals.

## KIENBOCH'S DISEASE

This is a puzzling affection in which the lunate bone becomes softened and deformed. The ætiology is doubtful and it is not even certain to which group of diseases it belongs. A similar condition occurs in the scaphoid, when it is known as *Preiser's disease,* and occasionally the other carpal bones are affected.

There is often a history of trauma but sometimes the violence is comparatively insignificant, and sometimes there is no known trauma. Some surgeons regard the condition as a primary aseptic necrosis on which a pathological fracture is superimposed, others think there is a primary fracture, and yet others believe there is a low grade osteomyelitis. None of

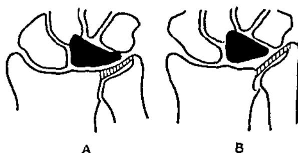



FIG 263 To show relation of the semilunar bone to the radio-ulnar joint (after Persson)
A In Kienboch's disease, and
B In a normal wrist

these theories explain fully the variable relationship with trauma. Hultén and Persson, however, have pointed out that the proximal surface of the radio-carpal joint is formed partly by the radius and partly by the triangular ligament, i.e. part is hard and part is soft. They claim that the relation of the lunate bone to the junction of the hard and soft surfaces varies, and that the disease has a marked predeliction for wrists in which the centre of the lunate is opposite the junction (Fig. 263). They also advance histological evidence which suggests that necrosis of the bone is due to minute

Penicillin is of undoubted value for the more severe infections and their complications. It is also probable that infection can be aborted if treated very early before there is pus formation and tissue necrosis. There is, however, uncertainty as to whether the course of the ordinary established paronychia or whitlow is shortened by penicillin, and the most important single factor in treatment is early and adequate drainage.

**Clinical Types.** There are five important clinical types of infection of the hand. They will not be discussed exhaustively and only the salient features of each will be indicated.

1. Paronychia.
2. Whitlow.
3. Palmar space infections.
4. Suppurative tenosynovitis.
5. Lymphangitis and cellulitis.

## Paronychia

Infection is introduced beneath the cuticle (perionyx) as the result of careless manicuring, or by a pin-prick, or from a "hangnail." The first signs are pain, redness and swelling of the skin around the side and base of the nail; later a bead of pus collects making a point of acute tenderness, and finally the pus spreads around the base of the nail, and then beneath the nail where it collects in the lunula. If left untreated, the nail-bed is *partly destroyed and the nail permanently discoloured and deformed.*

**Treatment.** Before the infection has spread beneath the nail it is sufficient to make an incision through the cuticle with the knife held horizontally, a wide sweep being made from one angle of the nail to the other (Fig. 265A). A tiny strip of a single thickness of tulle gras is placed in the incision to keep it open; it can usually be removed the next day and the wound should be healed three or four days later.

When there is infection beneath the nail wider drainage is essential, and if there is any doubt it is better to err on the radical side. An incision is made through the cuticle at the base of the nail as before, then the nail is cut transversely just distal to the lunula with sharp-pointed scissors and the base of the nail removed (Fig. 265B). A dressing of tulle gras is applied and the raw area epithelializes in about a fortnight; a new nail then grows and pushes off the remainder of the old one.

With the most severe infections cuts should also be made sloping backwards and slightly outwards from each angle of the nail, care being taken not to injure the matrix, and a strip of tulle gras is placed beneath the flap *to keep it open (Fig. 265C).*

## Whitlow

(*Synonym*) Felon

A whitlow is an acute infection of the pulp space on the front of the finger tip. The bacteria are usually introduced at the time of injury through a puncture wound such as a pin-prick. In about twelve hours, or at most a day or two, the pulp becomes tense, swollen and indurated, the temperature is raised, and there is intense throbbing pain and exquisite tenderness. A

## PYOGENIC INFECTION OF THE HAND

The economic and social importance of infection of the hand is so great that no excuse is needed for emphasizing it. In this age of mechanization minor injuries occur with startling frequency both in the factory and the home, and only too often they lead to suppuration. Neglect of the injury and of the ensuing infection means weeks of suffering, but both the period of disablement and the residual disability can be greatly reduced by careful prophylaxis and proper treatment.

**Treatment.** Treatment of the ordinary infected finger is a simple business and perhaps for this very reason it is undertaken by almost every doctor, whether or not he is particularly interested in work of this sort. As was the case when fractures were first segregated and treated in special clinics, the segregation of infections of the hand for the purpose of treatment is followed by a striking reduction in both the period of disability and the number of complications. At one hospital, when hand infections were transferred from the casualty department to a special clinic, the period of disability was halved even though treatment was carried out by the same medical officers with only a little additional supervision. Another effect of establishing a special clinic is that it soon becomes known to the workers and housewives of the district and patients attend earlier in the course of the infection.

Prophylaxis. Many infections, but not all, can be prevented. Cuts and abrasions are satisfactorily cleansed by prolonged washing with soap and water, and this is much more effective than dabbing on an antiseptic. With pricking injuries the infecting bacteria are introduced deeply into the tissues through a puncture wound at the time of injury and proper cleansing is impossible. Prophylaxis must therefore be directed to preventing the injury, and much can be done by an observant factory medical officer working with a co-operative management. Care of the hands, particularly of the nails and cuticles, is of great importance and in some circumstances it is an economic proposition to provide women operatives with free manicure during working time! Once infection is established immediate surgical treatment is essential and this should be impressed both on the workers themselves and on all those concerned with their medical care.

Operation. Operations for the release of pus or for the relief of tension should always be performed under general or regional anæsthesia, and in a bloodless field. "A stab at a whitlow with a quick gas" is a surgical crime—the anæsthetic must last long enough to permit a deliberate operation. A bloodless field is secured by a pneumatic tourniquet applied above the elbow, or by rubber tourniquet twisted, not tied, round the finger.

Chemotherapy. The routine, systemic administration of penicillin is under trial at a number of clinics. Minor infections are seldom admitted to hospital because of the shortage of beds and therefore four-hourly injections are troublesome to arrange. The alternatives are twice-daily administration of 150,000 units in beeswax or oil, or 250,000 units in water, and it is probable that both are reasonably satisfactory.

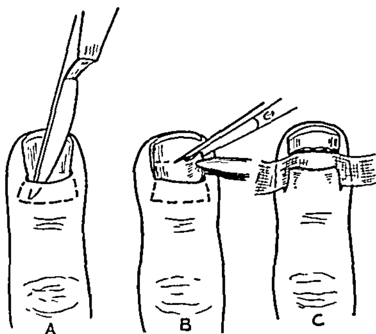



FIG 265 Incisions for paronychia (see p 337)

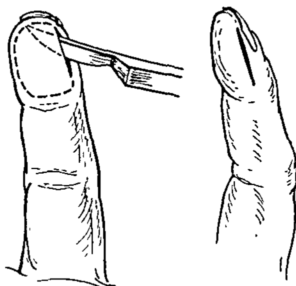


FIG 266 Incision for pulp space infection

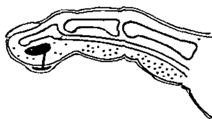


FIG 267 Subcuticular abscess communicating with the pulp space

small abscess forms after several days and then the pain becomes somewhat less. In the absence of early treatment the blood supply of the distal part of the terminal phalanx is cut off, the bone becomes infected and the finger and nail are permanently deformed. The abscess may also spread to the terminal interphalangeal joint and to the sheath of the flexor tendon.

*A Subcuticular Abscess* at the tip of the finger should be viewed with suspicion because it nearly always communicates by a sinus with a deep abscess in the pulp (Fig. 267). If the deep abscess is opened at once with the usual lateral incision, the tiny sinus will probably heal without a scar; but if it is not opened, the sinus enlarges and the resulting scar at the front of the finger is disfiguring and disabling.

**Treatment.** *Within a few hours of injury, and whilst there is no more* than the slightest amount of pain and tenderness, it may be possible to control the infection by the administration of penicillin. After this stage has passed immediate operation is essential, and to delay it is to take an unjustifiable risk of the bone becoming infected. The finger must be opened as soon as it has become swollen or tense, and abscess formation should not be waited for. When no pus is found at operation the surgeon should not be disappointed, but pleased that he operated so early.

"Alligator mouth" and "hockey stick" incisions are unnecessary and they cause undesirable scarring which interferes with the tactile function of the finger tip. A lateral incision gives adequate drainage provided the knife sweeps right across the tip of the finger to the opposite side. The incision begins 1/10th inch from the nail and runs proximally, and very slightly towards the palmar surface, for a distance of $\frac{3}{4}$ to 1 inch. The knife is then swept across the pulp of the finger as shown in Fig. 266; the point should be palpable beneath the skin of the other side. Even when pus is encountered immediately below the skin incision, the complete operation must be performed in order to divide the longitudinal septa of the pulp space and ensure proper drainage. Great care must be taken not to injure either the bone or the distal end of the flexor sheath with the point of the knife or it may infect them. After operation a small wick of tulle gras is inserted to keep the wound open, it is removed after twenty-four to forty-eight hours and healing takes place in a few days.

OSTEOMYELITIS. If a whitlow that has been opened properly fails to heal in a few days, or if there is extensive soft tissue necrosis when the finger is first seen, it is probable that the bone is infected. Radiological evidence of osteomyelitis does not appear for about a fortnight but administration of penicillin should be commenced as soon as the condition is suspected. *50,000 units are given four-hourly, or if that is impossible* 250,000 units twice daily for seven days, and for longer if the wound remains unhealed. X-rays are taken every four days, and if a sequestrum is shown, it should be removed. Rarefaction of bone increases during treatment with penicillin (p. 360) but this is not a sign of advancing infection, and no operation on bone should be performed unless there is definite evidence of sequestration.

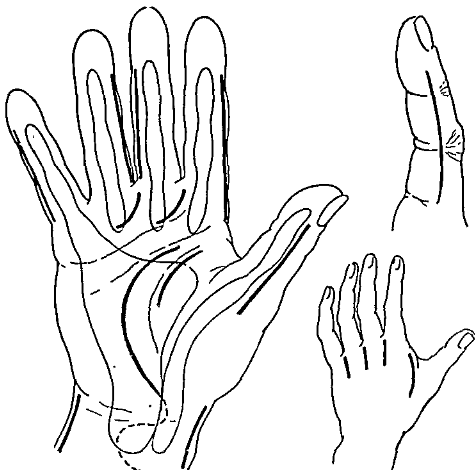


FIG 268 Incisions in the hand (modified from Bunnell).

blunt pencil. The temperature is raised and other general signs of infection are present. After the sheath has burst movement is less painful; the hand, however, is more swollen and the dorsum becomes œdematous because the fascial spaces are then infected. When the ulnar bursa is involved all the fingers and also the wrist are held semi-flexed and stiff; the hollow of the palm disappears, there is swelling above the transverse carpal ligament and fluctuation may be detected.

**Treatment.** Penicillin has greatly improved the prognosis, and if treatment is begun with the same urgency as after an abdominal catastrophe, there may be complete functional recovery. The most satisfactory routine has not yet been established but *in very early cases* it is probably unnecessary to make the extensive incisions that were previously practised; the systemic administration of penicillin is begun at once, and the sheath is incised at each end and washed out with a solution of penicillin. When treatment is commenced later, the whole length of the sheath must be opened and, if it is involved, the corresponding palmar bursa.

The incisions are illustrated in Fig. 268. They are planned so as to avoid injuring the neuro-vascular bundles, and to avoid crossing the palmar flexor creases which leaves a painful and disfiguring scar. The finger and thumb are opened on one side only by an incision placed exactly between

## Palmar Space Infection

The hand is divided by septa into a number of spaces containing loose areola and fibrous tissue which is traversed by nerves, blood vessels, tendons and muscles. The spaces are named the web space, the mid-palmar space, the thenar, hypothenar and dorsal spaces, and the quadrilateral space of the forearm. Infection enters by puncture wounds, from cracks in the skin, and by extension from infected tendon sheaths. If neglected, it may spread to the tendon sheaths and joints.

The affected part of the hand gradually swells, the skin becoming indurated, œdematous and thick; wooden hardness indicates that suppuration has commenced and pus is present. *Movements of the fingers are* restricted and painful when tendons or muscles pass through the infected space. Tenderness is accurately localized and this assists with the differential diagnosis from suppurative tenosynovitis.

**Treatment.** Infection, if treated *very early*, may be controlled by the administration of penicillin, but when an abscess has formed it should be drained without delay. The mid-palmar space is approached by the same incision as for the ulnar bursa, and the quadrilateral space as for the extension of the ulnar bursa into the forearm (Fig. 268). The thenar and hypothenar spaces are approached from the back of the hand but a palmar incision is sometimes required as well.

**Web Space.** This is the commonest type of fascial space infection. It often occurs in manual workers, the infection entering through cracks which form around callus and blisters on the palm of the hand. The web rapidly swells, at first in the front, and soon afterwards at the back of the hand. Although the pus collects chiefly in the palm, the abscess usually points dorsally; it tracks between the metacarpals which constrict it, hence the name "collar button" abscess. Two incisions are usually necessary for drainage—a curved palmar incision as for the palmar extension of a digital flexor sheath, *and a straight dorsal incision about* one inch long between the heads of the metacarpals.

## Suppurative Tenosynovitis

Infection of a tendon sheath is one of the most serious affections of the hand and unless rapidly controlled it causes disastrous crippling. The infection is often introduced through a puncture wound in one of the creases in front of the finger where there is no subcutaneous fat, or by direct spread from a whitlow. It spreads very rapidly to involve the entire sheath including, in the case of the thumb and little finger, the radial or ulnar bursa. The sheath is distended with pus, the tendons lie in a pool of pus, their blood supply is cut off and they become necrotic. Later the sheath bursts and the fascial spaces of the palm are infected.

The affected finger or fingers are held stiff in a semi-flexed position and both active and passive movements are extremely painful. The area of the tendon sheath and its extension into the palm are exquisitely tender and can be accurately mapped out by gentle pressure with the point of a

## TUBERCULOSIS

### Tuberculous Tenosynovitis

Tuberculous tenosynovitis is a disease of adult life which affects the tendon sheaths of the hands more often than those of other parts of the body, and the flexors more often than the extensors. Infection of the right hand is more common than of the left, and many patients are artisans. These observations are sometimes quoted in support of the theory that the infecting bacilli are introduced through the skin of the hand. Coincident active pulmonary disease is, however, unusual, and if cutaneous inoculation were common, it might be expected that the source of the bacilli would often be open pulmonary disease. Although implantation infection from handling diseased meat certainly occurs at times, it is probable that, as is the case with joints, dissemination usually occurs via the blood stream from the mediastinal or thoracic lymphatic glands.

**Pathology.** The infection commences in the synovial sheath, usually in the palm of the hand. It is of low virulence and spreads slowly over a period of years until ultimately the radial and ulnar bursæ and their extensions into the forearm are involved (Fig. 268). The sheath is thickened and infiltrated with typical tuberculous granulation tissue which spreads around the enclosed tendons. At an early stage the bursal sac is distended by a straw-coloured effusion, but later the fluid becomes more viscous and contains "rice bodies" and "melon seed bodies." These bodies, which are almost pathognomonic of tuberculous infection, are composed of fibrin deposited by the fluid exudate and rolled into concretions by the continuous movement of the tendons. Sometimes the sheath ruptures, setting the fibrinous bodies free in the palmar space. Large masses of firm caseous material involving all structures in the palm of the hand are occasionally formed.

The tendons lie in a bed of tuberculous material but are not usually invaded by it. After some time, however, they fragment and partially disintegrate, probably because their blood supply is interrupted. Even whilst the infection is progressing in some areas, healing by fibrosis takes place at others, and the tendons soon become bound together by a mass of fibrous tissue. The median nerve, owing to its position, is also surrounded by granulation tissue and this may cause pain and paræsthesia, but the power of conduction is seldom interfered with.

**Signs and Symptoms.** The onset is insidious and the history may extend over a number of years. The first complaint is of gradual swelling and stiffness of the fingers. Later the loss of power becomes marked, the fingers are held in a semi-flexed position and they cannot be fully flexed or extended. Finally, when the tendons become adherent, all movement is lost. There is seldom pain in the forearm or palm, but there may be numbness and tingling in the thumb and inner three fingers due to compression of the median nerve.

On examination, there is a swelling of doughy consistence in the palm

the volar and dorsal creases; this is just dorsal to the mid-point and therefore dorsal to the neuro-vascular bundle. When infections of the palmar and radial bursæ are treated late, incisions are necessary both in the palm and at the wrist proximal to the transverse carpal ligament.

After operation the wounds are held open with strips of tulle gras reaching down to the sheath, but not through it. Stringent aseptic precautions are taken and all dressings should be done in the theatre. The fingers are kept at rest for two or three days and then active movements are begun in order to prevent the tendons becoming adherent. In favourable circumstances healing takes place in two to four weeks, but full restoration of function may take longer.

*Once a tendon has been deprived of its blood supply no chemotherapy* can save it. A dead tendon looks grey and shaggy, and if left in the hand it acts as a foreign body and delays healing; therefore, as soon as its fate is beyond doubt, it should be removed. The wound can then heal with a minimum of fibrosis and a tendon transplant is possible at a later date.

## Lymphangitis and Cellulitis

The hand is covered by a close network of lymphatic vessels and therefore infection by a virulent streptococcus that happens to find its host a favourable medium for growth spreads like a fire in a timber yard. The bacteria may enter through a cut or abrasion anywhere in the hand, often a puncture wound, and within a few hours the finger or the part of the hand concerned begins to swell and throb. There is usually a severe constitutional disturbance; the onset may be heralded by a rigor, especially if the blood stream is also infected, the temperature is very high and the patient soon becomes profoundly ill. The spread of infection up the arm is marked by red streaks which map out the lymphatic trunks; the lymphatic glands in front of the forearm and elbow and in the axilla become enlarged and tender.

The spread of infection may *be so rapid and toxæmia so profound that* the patient dies within forty-eight hours. On the other hand, in favourable circumstances and with early treatment, it may subside with equal speed. The typical infection follows a course between the two extremes and the forearm becomes indurated and brawny, finally breaking down with a diffuse liquifying cellulitis. The fascial spaces, tendon sheaths and joints of the hand are often involved, particularly when the infection starts in the palm. In less severe infections, the cellulitis is localized and subcutaneous abscesses form along the path of the lymphatics.

**Treatment.** The course and prognosis have been greatly modified since penicillin became available, and provided administration is begun within a few hours of onset, resolution may be expected without suppuration. When started later the spread of infection may be arrested, but even so convalescence is likely to be long and stormy. Incisions must not be made at the stage of lymphangitis because fresh tissue spaces are thereby opened to infection; pus should, however, be liberated when abscesses have formed whether in tissue spaces, tendon sheaths or joints.

## Tuberculosis of the Carpus

Tuberculous arthritis affecting the wrist is infrequent at all ages but it is relatively more common in adults than in children. The pathological condition is the same as at other joints (p. 374), but because of the free communication between the synovial spaces, the infection spreads throughout the carpus and there is much destruction of bone.

In a typical case the classical symptoms of tuberculosis are present, that is pain, spasm and deformity. The wrist is held partly flexed, and the fingers are extended at the metacarpo-phalangeal joints and flexed at the interphalangeal joints. Wasting of the hand and swelling of the wrist are very obvious, and multiple sinuses are common.



Fig 270 Tuberculous disease of the carpus

X-rays show the usual appearance of loss of outline, diminution of joint space, generalized rarefaction and the destruction of bone (Fig. 270).

**Treatment.** This is essentially conservative but it must be conducted in favourable general conditions. The prospect of recovery is greatly reduced if a patient in poor circumstances is permitted to remain on a meagre diet in an overcrowded home.

The wrist is fixed in about 30° of dorsiflexion in a plaster cast. The cast should not extend beyond the proximal palmar crease in order to permit free movement of the fingers. If sinuses are present or threaten to form, the plaster is bivalved, or a metal splint is applied. When the disease is quiesent it is desirable to give permanent protection by performing an arthrodesis (p. 332)

of the hand and the forearm. The swelling is divided into two parts by the constriction of the transverse carpal ligament, and fluctuation between them can be demonstrated. Crepitus is sometimes felt on movement of the fingers but this is not a constant sign. The diagnostic features are impairment in function, swelling which varies from time to time and the absence of pain.

**Treatment.** CONSERVATIVE. Good results are said to follow conservative treatment but it takes a very long time and recurrence is not uncommon. Fibrinous bodies are evacuated through small incisions above and below the carpal ligament, and then the hand and fingers are splinted in the position of rest for a prolonged period (Fig. 269). There is some atrophy of muscles and stiffness of the fingers afterwards, but good function ultimately returns provided the tendons have not been destroyed.



FIG 269 The position of rest of the hand is that which it assumes naturally when the arm is hanging by the side

RADICAL EXCISION of the entire tuberculous mass has the advantage that the duration of treatment is greatly reduced and the risk of recurrence is possibly smaller (Kanavel). A longitudinal incision is made in the midline of the forearm and curved across the hand, and the transverse carpal ligament is divided to expose the whole tendon sheath. The sheath is then dissected away in its entirety taking meticulous care to preserve every nerve filament and small blood vessel. The hand is used as soon as the wound has healed and there is a rapid return of function if the damage caused by the disease is not too great.

## CONGENITAL DEFECTS

Congenital defects of the hands and the feet conform to a similar pattern, and therefore they will be described together.

It is known that nearly all types of defect are sometimes hereditary although sporadic cases also occur. Hereditary defects may recur in identical form in successive generations, but often only a tendency to malformation is transmitted and the exact form of the defect varies. It appears that the hereditary influence acts as a check to development at a critical stage, and the nature of the resulting deformity depends on the severity of the check and the embryonic stage at which it occurs (Bagg cit. Bunnell). Thus a check acting on the limb of a fœtus aged two and a half weeks may produce abrachius, at three weeks it causes polydactylism, and at six weeks syndactylism. Non-hereditary defects may be caused by a check to development of a different type, for example maternal rubella.

Congenital defects are numbered in countless variety, but certain of them recur with sufficient frequency to be grouped into types that can be named. A few illustrative types only will be mentioned briefly.

### Radio-Ulna Synostosis

This is a rare congenital defect in the development of the bones of the forearm. It is usually bilateral. Wilkie describes two types :—

1. The adjacent borders of the upper ends of the radius and ulna are fused for a distance of one or two inches. The head of the radius may be absent or joined to the ulna (Fig. 272).

2. There is in addition a congenital dislocation of the head of the radius, sometimes forwards but usually backwards. Fusion between the bones is at a slightly more distal point than in type 1.



FIG. 272 Radio-ulnar synostosis

In both types the forearm is pronated and the movements of the pronation and supination are absent.

Operative treatment appears at first sight to be attractive but it is seldom successful because the soft tissues are involved in the developmental defect. The disability is less than might be expected because of the compensatory movements at the shoulder.

## Tuberculous Dactylitis

The joints of the fingers rarely suffer from tuberculous arthritis, but the metacarpals and phalanges are occasionally the seat of tuberculous osteitis. Several bones may be affected at the same time and the condition is sometimes bilateral and symmetrical.

The infection commences in the medulla which is transformed into a mass of tuberculous granulation tissue. The cortex is eroded from within, and there is extensive subperiosteal bone formation. Ultimately the cortex is destroyed and the bone then appears to be greatly expanded (Fig. 271). The formation of small sequestræ is common, and often the skin is eroded leaving a sinus.

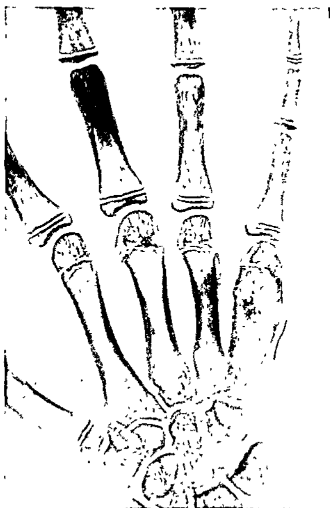


FIG 271 Tuberculous dactylitis (cf, Fig 208, p 263)

**Treatment.** Conservative treatment by prolonged fixation with the affected fingers in the position of rest is sometimes successful, but if the integrity of the skin is threatened, the underlying bone should be exposed at operation and the infected tissues cleared out as thoroughly as possible. Amputation of the finger or excision of a metacarpal may be preferable when only one bone or a single digit is involved.

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### Congenital Absence of the Radius or Ulna

This is a rare defect but the resulting deformity is serious, and when bilateral it is most disabling. Other congenital defects of the hands and fingers are often present at the same time.

The radius may be entirely absent, or it may be represented by a small fragment at the upper or lower end; the ulna is short, curved, and thick, and the lower end articulates with the carpus. The hand is usually small, deviated to the radial side, and partly flexed.

Congenital absence of the ulna and congenital shortening of the ulna are comparable deformities, and rather more uncommon than absence of the radius (Fig. 274).

Treatment of both deformities is difficult because of the associated soft tissue defects. The wrist should be splinted from birth to reduce the deformity, and at two or three years of age it may be possible to correct it further by excision of contracted tissues, and by tenotomies. The bone is straightened by osteotomy and grafted, and finally it is fused to the carpus at a suitable angle.

**Congenital Absence of the Tibia.** This is the corresponding deformity in the lower limb and it is equally difficult to correct (Fig. 273). Even if the leg and foot can be straightened, the leg is so short that it is of less service than an artificial limb. Amputation is usually desirable and it may be performed at three or four years of age. The amputation should be of the Symes type and then an ordinary below-knee prosthesis adapted for an end-bearing stump can be fitted and the function is excellent.



Fig 273 Congenital absence of the tibia



FIG 274 Congenital absence of the ulna (by courtesy of Mr P. H. Newman)

## Clinodactylism

Lateral deflection of a finger or toe from the normal straight position is a common hereditary characteristic (Fig. 276). The little finger and forefinger are most frequently affected and usually they are bent at the level of the middle phalanx or the terminal interphalangeal joint towards the median axis of the hand. The deformity is not often severe enough to require correction but when necessary this can be done by osteotomy of the middle phalanx. This operation must be performed during early childhood.

Flexion of the little finger is another common familial defect (Fig. 275). The finger may be flexed as much as 90° but often the amount is smaller. In some people the deformity appears to increase during late adolescence or early adult life. Correction in adults is unsatisfactory because one or both the interphalangeal joints are deformed, and because the soft tissues on the palmar surface are contracted. In young children correction is simple and it is only necessary to perform an osteotomy of the distal part of the proximal phalanx and fix the finger straight whilst it unites. The bone rapidly remodels during growth and becomes normal in shape.



FIG 275 Congenital flexion deformity of the little fingers (Note the mallet finger on the right hand)

## Syndactylism

Webbing of the fingers or toes is a congenital anomaly in which two or more digits are enclosed in the same sheath of skin (Fig. 276). The skin may *pass directly from one finger to the next, or else it dips between them* to make a thin web consisting only of two layers of skin. The web may extend to the tips of the fingers or terminate at any intermediate point.

Operation gives an excellent functional and cosmetic result but it should be postponed until about three years of age. It is essential to cover the bottom of the cleft with skin or else the scar contracts and draws down the skin of the hand to reform the web. Flaps of ample size to cover the cleft are cut first, and then dorsal and volar flaps are so fashioned as to cover as much of the fingers as possible; the raw areas remaining are filled with skin grafts (Fig. 277).



Fig. 276 Web-fingers A bony ridge between the fingers, as shown here, is very uncommon Note also the lateral deflection of the little finger

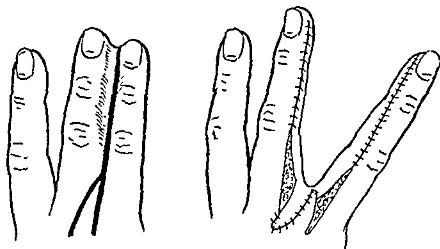


Fig 277 Operation for web-fingers

## Madelung's Deformity

Several deformities of the wrist are described under this name and are probably different stages in the evolution of the same defect (Moore):—

1. Forward subluxation of the wrist with laxity of the ligaments.
2. Forward subluxation of the wrist combined with posterior dislocation of the ulna.
3. Increased curvature of the radius and dislocation of ulna. The lower epiphysis of the radius is oblique, and the ulna is relatively long and rests against the dorsum of the carpus.

The onset is nearly always during early adolescence and is accompanied by pain. Deformity develops gradually during the next few years. There is often, but not always, a history of trauma, and this is sometimes alleged to be the cause of the defect. Trauma does not, however, explain the uniformity of age at onset, nor the rarity of the condition which is more likely to be due to a congenital disturbance in growth of the lower epiphysis of the radius.

Adults with this deformity do not always have symptoms of sufficient severity to warrant operative interference, but operation is occasionally necessary for pain, or to improve the appearance of the wrist. With deformities of the first two stages, it may be sufficient to fasten the ulna in position by a sling of fascia passed round the neck of the bone and through the radius. With deformities of the final stage, the alignment of the wrist joint is corrected by osteotomy of the radius and the ulna is shortened.



Fig. 278 Madelung's deformity

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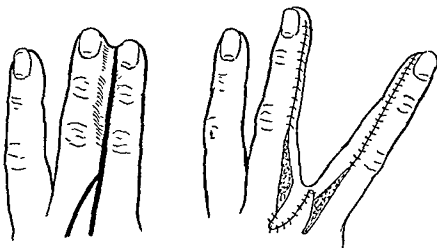


Fig 277 Operation for web-fingers

## Megalodactyly

Giant overgrowth may affect any one of the fingers, and sometimes more than one. The defect is not known to be hereditary and is of a different nature to those already discussed because it is not caused by an arrest in development. The bones are enlarged in all dimensions and the soft tissues are hyperplastic. It is unusual for the metacarpals to be affected although in the example shown in Fig. 280 they are somewhat thickened.




Fig 280 Megalodactyly

## "Lobster Claw" Hand and Foot

This congenital deformity is almost always hereditary although it happens that the boy illustrated in Fig. 279 was not known to have any similarly affected relatives. The function of such a hand can be remarkably good and serves for all but the finest work. When the cleft between the digits is poorly marked, function can be improved by deepening it. A "lobster claw" foot usually gives its possessor excellent service and causes but little disability.

A woman with such a hand, and whose sisters, mother and grandmother were all affected, was asked when she announced her engagement to be married, if she intended to have children. She replied that of course she did because she found her hands no disadvantage, nor did the other members of her family.



Fig 279 "Lobster claw" hand The function was improved by removing the two rudimentary metacarpals and deepening the cleft



Fig 281 Chronic osteomyelitis of the tibia (From the Hunterian collection of the Royal College of Surgeons of England.)



Fig 282 Chronic osteomyelitis of the ulna showing a massive sequestrum and great thickening of the bone.

is seldom absorbed in the presence of infection, and healing is unable to occur until the sequestrum has been discharged spontaneously or removed surgically.

Osteoporosis (*caries*) occurs when the bone is eroded and replaced by granulation tissue. This process is more typical of the granulomata (e.g. tuberculosis) than of pyogenic infection although it also occurs in the latter.

Sclerosis of the bone surrounding an inflammatory zone is an almost invariable reaction during the stage of healing. New bone is deposited in the cancellous spaces making it more dense.

## CHAPTER X

# PYOGENIC INFECTION

## OSTEOMYELITIS

Osteomyelitis is an inflammatory process resulting from the deposition and growth of micro-organisms in bone. The infection may reach the bone by three routes :—

1. By the blood stream, and occasionally the lymphatics, from a primary focus of infection elsewhere.
2. By direct spread from infected tissues in the vicinity.
3. From outside the body as the result of a wound.

The course varies with the mode of infection, the organism concerned and the resistance of the host. It may be acute, sub-acute or chronic.

Acute Osteomyelitis is usually the result of a blood-borne infection (acute hæmatogenous osteomyelitis). Direct infection through a wound seldom causes a virulent acute osteomyelitis for two reasons, firstly because the infection commences on the surface of the bone and therefore the deeper vessels are not obstructed in the same way as when it is blood-borne, and secondly because drainage is automatically provided at the time of injury.

Sub-acute Osteomyelitis may be due to a blood-borne infection by a micro-organism of comparatively low virulence, or it may be caused by the spread of infection from a neighbouring structure, or by direct infection through a wound.

Chronic Osteomyelitis may arise as a sequel to acute or sub-acute osteomyelitis, or the infection may be of such low virulence that the early stages are symptomless.

### Pathology

All the constituent parts of the bone are involved and periostitis, osteitis and osteomyelitis cannot be regarded as separate entities. The ordinary pathological changes that accompany infection are modified when they occur in bone because of its structure and the arrangement of its blood supply. The following process, all or several of which may occur simultaneously, can be distinguished.

Necrosis. The smaller blood vessels are contained in rigid channels in th [illegible]
to es [illegible]
and [illegible]
or lo [illegible]
[illegible]
area [illegible]

The periosteum is stripped up and a subperiosteal abscess is formed which rapidly encircles the bone and eventually breaks through into the soft tissues. The adjacent joint is seldom involved although occasionally it is infected by direct spread through the epiphysis, or indirectly from the soft tissues. Direct spread to the joint is rare in children, except at the hip, because of the barrier formed by the epiphysial disc.

Necrosis of bone occurs to an extent depending on the stage at which treatment is instituted and how widely the infection has spread; it varies from a negligible amount up to death of almost the entire diaphysis.

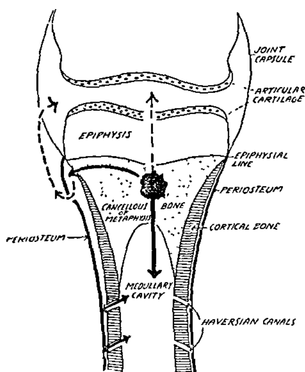



FIG 283 Methods of spread of acute hæmatogenous osteomyelitis at the upper end of the tibia

## Clinical Features

There is sometimes but not always a history of injury. The first complaint is usually of pain and tenderness near a joint which increases rapidly in intensity; jarring is painful and small children refuse to use the limb at all. Constitutional signs of general infection precede or immediately follow the onset of local symptoms; the child is obviously ill, the face is flushed, the tongue furred, the pulse rapid and the temperature raised to 103° or 104°.

On examination there is tenderness to pressure which is localized to the immediate neighbourhood of an epiphysial disc. It is important to note that the tenderness is over the bone, not the joint, and special care is necessary to establish this point. The joint can usually be moved gently over part of its range without causing pain provided the weight of the limb is supported, but full flexion and extension are nearly always painful. At an early stage there is little or no swelling but later the overlying soft

Periosteal Bone Formation varies considerably in amount; it is usually extensive when the periosteum is stripped up by an abscess or is separated by a layer of granulations from necrotic bone. When there has been massive death of bone forming a large sequestrum the whole area becomes surrounded by new periosteal bone which is then known as the *involucrum*. The involucrum is perforated by cloacæ through which the discharge can escape (Fig. 281).

## ACUTE HÆMATOGENOUS OSTEOMYELITIS

This is a condition in which infection in bone occurs during the course of a generalized disease—bacteræmia, septicæmia or pyæmia. It is essentially a complaint of childhood usually occurring before the age of ten years, and in at least 90 per cent of cases before growth of the long bones has ceased. Males are affected more frequently than females in the proportion of about three to one. The disease involves children living in the poorest conditions more frequently than those of well-to-do parents and the incidence is decreasing, perhaps because of improvement in the general standards of hygiene and cleanliness.

### Pathology

The infecting organism is a staphylococcus aureus in about 80 per cent of all cases and a streptococcus in 10 per cent. In infants under three years of age, however, streptococcal infection is commoner than staphylococcal, and although the initial attack is more virulent and the mortality greater, there is generally less destruction of bone and the sequelæ are less serious. Infection by almost every other known micro-organism has been reported, and simultaneous infection by two or more is not unusual.

The commonest sites of infection in order of frequency are the upper end of the tibia, the lower end of the femur, the humerus, the fibula and the radius. Every other bone including the skull, mandible, vertebræ, carpal and tarsal bones are occasionally involved.

The infecting bacilli are carried in the blood stream from a primary focus elsewhere in the body, perhaps a boil, pimple or other minor lesion of the skin, or perhaps an infection of the naso-pharynx. The initial bony focus is usually in the metaphysis of a long bone (i.e. the cancellous bone adjacent to the epiphysial disc), and occasionally in the epiphysis, in the medulla or under the periosteum. The reason for the frequency with which the metaphysis is affected is not certain, but it has a particularly good blood supply and the channels containing the capillary vessels are narrow; this both slows up the rate of flow of the blood and reduces the space available for mobilization of the local defences. Minor trauma causing capillary hæmorrhage in the bone is often given as a predisposing cause but its importance is uncertain.

When the infection has gained a hold in the metaphysis a small abscess is formed. As the abscess grows, tension develops and the pus tracks in the directions of least resistance, that is centrally to the medullary cavity, and outwards along the epiphysial disc to the subperiosteal region (Fig. 283).

of the patient, and the stage at which treatment is begun. There are two clinical types depending on whether the picture is dominated by the infection in bone or by the general infection.

(*a*) *Localizing Type.* This is the usual type. The infection is rapidly localized to a single focus in bone, and although the patient may be seriously ill, the bone infection is of chief importance.



FIG. 284 Acute osteomyelitis of the femur in a baby aged three weeks Penicillin was given 20 hours after onset, X-ray four weeks later

(*b*) *Fulminating Type.* The general infection completely overshadows the local condition in bone which may easily be overlooked.

**Localizing Type.** Experience with penicillin is as yet too recent to speak with certainty, but it does seem that the course is determined more by the time of commencing administration than by any other factor. On this basis three groups can be distinguished :—

1. TREATMENT COMMENCED EARLY, within a day or two of onset. The general signs begin to go within two or at most three days and the temperature returns to normal within a week ; the local condition subsides as rapidly and no soft tissue abscess is formed. No surgery is required. The limb returns quickly to normal and there is no fear of recurrence.

*X-rays* may show no changes at any stage, but sometimes after a fortnight there is a little necrosis of bone and some periosteal reaction (Fig. 284).

2. TREATMENT COMMENCED LATER, three or four days after onset. The infection takes rather longer to control and it is several days before the general symptoms begin to subside. A soft tissue abscess forms which may remain subperiosteal or break through and become subcutaneous. A

tissues become red, swollen and œdematous. There may be an effusion *into the joint even though it is not infected.*

There is usually a polymorphonuclear leucocytosis of 15,000 to 30,000; absence of a satisfactory white cell reaction gravely affects the prognosis. In staphylococcal infections the staphylococcal titre is raised. Blood culture is frequently positive.

**Diagnosis.** The clinical findings of pain and tenderness at an epiphysis in a child that is ill are sufficient evidence to call for immediate treatment. Soft tissue swelling and œdema are late signs and to wait for their appearance may cause irreparable damage to the bone. X-rays show no change in the structure of the bone until at least ten days after the onset of symptoms.

Occasionally there is pain in several bones *for the first day or so* and then the condition resembles acute rheumatism. A pyogenic infection, however, usually localizes rapidly to one bone and this, together with tenderness over a metaphysis and the hæmatological findings, should make the diagnosis clear. When there is any doubt treatment as for acute osteomyelitis should be *commenced at once.*

Acute suppurative arthritis may be simulated when acute osteomyelitis is accompanied by a serous effusion into the joint. The aspirated fluid is, however, clear on naked eye examination, whereas it is cloudy or frankly purulent in arthritis.

## Course and Treatment

Penicillin has revolutionized the treatment of both septicæmia and acute osteomyelitis. Septicæmia, except in fulminating cases, can be controlled, the course of the infection in bone greatly shortened, the subsequent morbidity reduced and the overall mortality, formerly in the *region of 20 per cent has been cut to 2 per cent.* Provided *the administration* of penicillin is commenced early it is probable that the bone will return to normal, and even if treatment is delayed, rapid control of the infection may still be possible. Surgery is often unnecessary, and in many cases the most that is required is to aspirate an abscess or provide drainage by a simple incision.

In accordance with the usual principles for the treatment of acute infection, immobilization is desirable. The part must, however, remain open for inspection and therefore a bivalved plaster is used for infection near the knee, a Thomas's splint with weight extension for the upper end of the femur, and an abduction splint for the humerus.

The optimum dosage of penicillin has not yet been established but the present practice is to begin with a very big dose and continue with smaller quantities for a considerable period. The initial dose may be 250,000 units followed by 100,000 units every four hours for forty-eight hours, or until the temperature is settling, and then 30,000 units four-hourly for at least two weeks. Continuous administration by intramuscular drip is preferred in some *hospitals for small children.*

The course depends on the virulence of the infection, the resistance

of the patient, and the stage at which treatment is begun. There are two clinical types depending on whether the picture is dominated by the infection in bone or by the general infection.

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small abscess should be treated by aspiration and injection of penicillin, but a larger abscess may require drainage by incision. A few surgeons prefer also to relieve tension in the metaphysis by making several holes in it with a drill. The wound, if one is made, heals quickly and the use of the limb may be resumed after a few weeks.

*X-rays* of these patients show an interesting series of changes. After about ten days, subperiosteal new bone is laid down and the affected part of the metaphysis commences to undergo patchy decalcification giving the bone a somewhat mottled appearance. Decalcification increases for some months and then the bone returns gradually to normal. It is evident that penicillin, by destroying the infection, converts a process of septic necrosis into one of aseptic necrosis. Areas of bone which were killed during the acute stage, instead of separating and becoming sequestræ as would have happened had they remained septic, are gradually re-vascularized—hence the increasing rarefaction—and ultimately they are reconstituted as normal bone (Fig. 285).

3. Treatment Commenced Late, after seven days or more (Fig. 286). The course is not unlike that when penicillin is not used and there is much local destruction of bone and extensive soft tissue abscesses are formed. The general toxæmia, however, is more readily controlled, fewer sequestræ *are formed, and healing is quicker. Soft tissue abscesses should be drained* by incision as soon as possible, and it may also be desirable to drain the metaphysis and the medulla by drilling. Healing may occur within a few weeks, but it may be delayed until the sequestræ have discharged themselves from the wound, or have been removed at operation. There is some evidence that enormous doses of penicillin are of value, say 500,000 or 1,000,000 units four-hourly for several days.

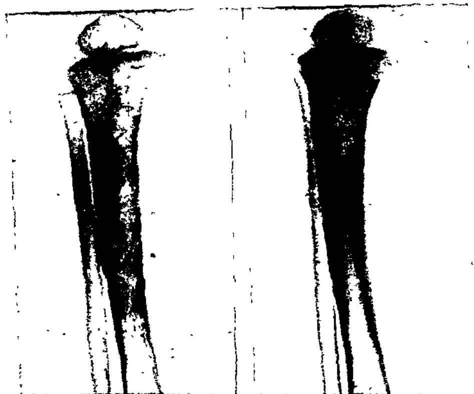
*X-rays* show extensive destruction of bone, sequestrum formation and deposits of new subperiosteal bone. When the infecting bacteria have all been destroyed, the normal reaction of sclerosis around an infected area does not take place. Some cases are recorded in which revascularization of sequestræ has occurred, and it has been suggested that the sequestræ, having become sterile, are treated by the body similarly to autogenous bone grafts.

Secondary infection of a joint, usually the knee, occurs occasionally and is satisfactorily treated by aspiration of the fluid and replacement with 100,000 units of penicillin. The penicillin should be given without waiting for the result of bacteriological examination if the naked-eye appearance of the fluid is suggestive of infection. It may be repeated every forty-eight hours if required (p. 371).

When treatment is commenced very late large parts of the diaphysis, even the whole of it, may be deprived of blood supply and become necrotic. Complete control of the infection may not then be obtained and the condition degenerates into one of chronic osteomyelitis. The dead bone separates as sequestræ; new bone is deposited under the periosteum (involucrum), and in the healthy bone surrounding the infected area (sclerosis); discharging sinuses may persist indefinitely (Figs. 281 and 282).



20th February, 1948 — 26th February, 1948



23rd April, 1948 — 5th August, 1948

Fig 285 Acute osteomyelitis of the tibia. Onset 3rd January, 1948; administration of penicillin commenced 40 hours later.



January, 1946



May, 1947

FIG 286 Osteomyelitis of the lower end of the femur of a girl aged eight years Treatment was not commenced until three weeks after the onset A massive sequestrum was removed four months later (January, 1946) and then the sinuses healed rapidly

**Fulminating Type.** The majority of fatal cases are of this type. The condition is primarily a septicæmia and osteomyelitis is but an incident in its course. Blood culture is always positive; Butler has shown that a colony count is of prognostic value, and when it is of the order of 500 to 1,000 per c.c. the prognosis is grave.

The patient becomes profoundly ill within a few hours of onset and the general condition deteriorates rapidly. There are often multiple embolic abscesses of which only some are in bone. Death may occur in twenty-four or forty-eight hours before there is time for penicillin to exert its effect.

The treatment is mainly that of the general condition. Very large quantities of penicillin should be given, say 500,000 units four-hourly until there is a sign of improvement. Body fluids must be maintained by parenteral administration of saline, etc. A localized abscess in bone may be drained if the general condition permits.

### Typhoid Osteomyelitis

Acute infection of bone by B. typhosus or paratyphosus is an occasional complication of enteric fever occurring in less than 1 per cent of cases. The lesion is most frequently subperiosteal and affects the shaft of a long bone or the body of a vertebræ, but any bone may be involved. The onset is usually during the convalescent stage of the fever; the temperature rises, the affected bone becomes painful and tender, and the overlying soft tissues and skin may show signs of inflammation. The amount of pus formed is small. On rare occasions an abscess becomes encapsulated in the bone and causes symptoms many years later.

Resolution often takes place without operation. The part is placed at rest and watched carefully; if definite suppuration occurs, the abscess should be incised, the pus evacuated and the cavity swabbed out. A chronic abscess is dealt with in the same way as a Brodie's abscess.

## CHRONIC OSTEOMYELITIS

Chronic infection of bone may be the result of incomplete resolution of an acute blood-borne infection, or it may be a sequel to a penetrating wound. Occasionally a blood-borne infection is subacute and *the stage of necrosis and new bone formation is reached without an initial acute illness.* Infection following gunshot or other penetrating wounds is often of a comparatively low-grade character from the start.

The pathological condition is essentially one in which there are infected cavities surrounded by sclerosed bone. The cavities may be single or multiple, of any size or shape, and they may communicate with each other and with the surface of the body by sinuses; they are filled with infected granulation tissue and may contain sequestræ. The involucrum, if present, often grows to a considerable thickness; it has a rough, pitted surface and is perforated by cloacæ that permit the discharge of pus (Fig. 281). The bone and sinuses become surrounded by masses of dense fibrous tissue in which bacteria may be encapsulated.

The X-ray appearances vary with the cause and extent of the disease. A sequestrum is usually more opaque than the surrounding bone and has clearly defined margins. Massive sequestræ often retain a more or less normal structure and may show division into cortical and cancellous bone. The reason for the apparent increase in density of sequestræ is not always clear. Sometimes it is due to the surrounding bone becoming decalcified whilst the sequestrum, which has no blood supply, retains its normal composition. This explanation, however, is not satisfactory in all instances, and there is some evidence that sequestræ undergo an actual increase in density. After healing the bone seldom returns completely to normal and some radiological evidence of past disease remains permanently.

### Course and Treatment

Established chronic osteomyelitis, whether due to an unresolved acute blood-borne infection or to a penetrating wound, follows a similar course

and requires similar treatment. The treatment of recent osteomyelitis caused by penetrating wounds is outside the scope of this book.

Penicillin has not the same dramatic effect as in acute infections and once an infection of bone has become chronic, it may remain a trial to the patient (and the surgeon) throughout his life. Sequestræ are without blood supply, and there is but a poor blood supply to the masses of dense fibrous tissue which surround the bone, and which replace the soft tissues destroyed by the original injury and the subsequent suppuration; drugs applied locally or administered parenterally are therefore unable to reach the infecting bacteria.

Chronic osteomyelitis may pursue one of three courses (Perkins).

1. The inflammation becomes quiescent but recurs at intervals of months or years without causing sinuses.
2. The inflammation becomes quiescent leaving a sinus extending to the interior of the bone and remains permanently in this condition.
3. There is a persistent sinus as in 2, and also recurring attacks of subacute inflammation.

**1. Recurrent Flares without Sinuses.** The original wound heals but the bone does not regain its normal radiological appearance. There are often areas of rarefaction and sclerosis but sequestræ are seldom present (*Fig. 287*). There is usually much fibrosis around the bone and extending into old cavities, and recurrence is as often due to infection remaining dormant in fibrous tissue as in bone. The patient may remain symptom free and lead a normal life for months or years, but sooner or later the infection flares up—some men wounded in the 1914-1918 war had their first recurrence as long as twenty-five years afterwards.

The recurring infection starts as an ache in the bone which gradually increases in intensity and may become really bad. There is some malaise and the temperature is raised, but toxæmia is not severe. There is local swelling and tenderness, and the skin may become red and œdematous.

Treatment. Most patients recover with rest. Parenteral penicillin in moderate doses (30,000 units four-hourly) greatly reduces the time taken to recover and diminishes the risk of a soft-tissue abscess forming. Surgery is contra-indicated unless there is an abscess which should be treated by incision, or by aspiration and injection of penicillin. Extensive bone operations should be avoided because they invalid the patient for a long time without reducing the risk of further recurrence.

**2. Persistent Sinuses without Flares.** Some acute infections subside leaving one or more sinuses which remain indefinitely but cause no more trouble than is involved in an occasional dressing. Often there is only enough discharge just to stain the dressing, and sometimes the sinus scabs over and only discharges occasionally. The surrounding skin remains fairly healthy.

A sinus indicates the presence of a sequestrum, a retained foreign body or a continued low grade infection of bone and soft tissues. It is important to decide which because a sequestrum or foreign body can be removed,



*Left*. Fig 287. Chronic osteomyelitis of the humerus with no sinus but frequent flares Several operations had been performed without lasting effect.

*Above*: Fig. 288 Chronic osteomyelitis of the ulna following a gun shot wound A sinus was present and healed rapidly after removal of the sequestrum.

but it is improbable that an infection of bone or soft tissues can be eradicated completely. X-rays are helpful, but not decisive; they show some sequestræ but not all, and they show metallic foreign bodies but not retained bits of clothing (Fig. 288). The presence of a foreign body is not conclusive proof that it is causing the trouble.

Treatment. Sinuses are very hard to cure and conservative treatment, including the administration of both local and parenteral penicillin, is usually without effect. Operation is only sometimes successful, and even if the wound does ultimately heal, subsequent flares are very common. The patient may be suffering comparatively little inconvenience and a decision to operate should not be made lightly; one attempt is usually justifiable, but if it fails repeated operations certainly are not.

Operations are performed under cover of systemic penicillin to prevent dissemination of infection. The sinus is followed to its source and cavities are opened by removing the overlying cortical bone. If a foreign body or sequestrum is found, it is removed and the wound is sutured without further interference. If no foreign body is found, the incision is extended and all fibrous tissue and infected bone are excised. It may be necessary to remove half or more of the circumference of the shaft before healthy bone is reached. The wound is not sutured but is lightly filled with *tulle gras* and allowed to granulate. When it has been possible to remove all the infected tissues, it is desirable a few days later to apply a split-skin graft ; after healing has taken place a full thickness skin flap is substituted, and if necessary, a strengthening bone graft is added.



FIG 289 Brodie's abscesses in the lower end of the femur and the upper end of the tibia which remained symptomless for nineteen years

**3. Persistent Sinuses with Flares.** These are a perpetual source of trouble. There is an infection of bone that is continually active and every now and then, perhaps every few months, it flares up violently. The discharge may be considerable and is very irritant, causing much trouble with the skin.

TREATMENT. The repeated attacks of inflammation are physically and economically incapacitating and radical treatment is required. Extensive *bone operations* of the type indicated above are usually attempted in the first instance, but only sometimes with success. When the lower

limb is affected, a prosthesis may give better service to the patient than his own diseased leg and amputation is then the procedure of choice.

### Brodie's Abscess

This is a special form of chronic osteomyelitis which occurs when the virulence of the infection and the resistance of the patient are nearly [illegible] bone is not accompanied by acute illness [illegible] small abscess is formed in the bone and [illegible] led in by a ring of dense, sclerosed bone. Such abscesses occur most commonly in the metaphyses of the long bones near the epiphysial discs. As growth proceeds the epiphysis moves away from the abscess and in adults may be some inches from it.

A Brodie's abscess often remains quiescent and symptomless for years but sooner or later it is likely to cause trouble. The bone becomes painful and tender, the overlying skin red and œdematous and there may be some fever but the constitutional symptoms are not marked. Recurrent attacks of this nature are a characteristic feature. The diagnosis is revealed by radiological examination (Fig. 289).

**Treatment.** The abscess is excised together with the dense bone surrounding it. A course of penicillin is started shortly before operation and the abscess cavity and wound are dusted with calcium penicillin before suture. Healing not infrequently takes place by first intention.

## SYPHILITIC OSTEOMYELITIS

Syphilitic disease in bone is becoming increasingly rare in western countries, so much so that when encountered the diagnosis is easily overlooked. The disease is a true spirochætal infection of bone. The appearances are diverse and many other conditions may be simulated, but certain typical forms occur at different periods of life.

### Infants

**Epiphysitis.** This is a characteristic manifestation during the first year of life. The typical lesion is an osteochondritis affecting the region of the epiphysial disc, usually at the lower end of the femur, sometimes at the upper end of the humerus. Radiographically there is a line of increased density adjoining the epiphysial disc, a line of rarefaction subjacent to this, and then another line of sclerosis. There are thus two lines of increased density separated by a line of rarefied bone (Fig. 290). The rarefied bone is necrotic and partly replaced by syphilitic granulation tissue; separation of the



FIG 290 Syphilitic epiphysitis

epiphysis may occur at this point. If the condition progresses to suppuration, a large abscess involving the joint may be formed. The response to anti-syphilitic treatment is good.

**Parrot's Nodes.** These are areas of periosteal thickening which occur on the skull around the anterior fontanelle and produce the so-called "hot-cross bun" appearance.

## Adolescents

**Periosteal Nodes.** These may occur on the long bones at any age, but most frequently in the young adolescent. Infection of the periosteum leads to inflammatory changes that terminate in the deposition of new bone beneath the periosteum. They are painless in children, but in adults there may be some aching and tenderness on pressure.

**Osteoperiostitis.** There is thickening of the periosteum over a large area of the bone and sclerosis of the subjacent bone. It is usually of symmetrical distribution and occurs characteristically in the tibiæ giving rise to the classical "*sabre tibiæ*." The sclerosis is probably due to reduction of the blood supply caused by syphilitic endarteritis of the periosteal vessels.

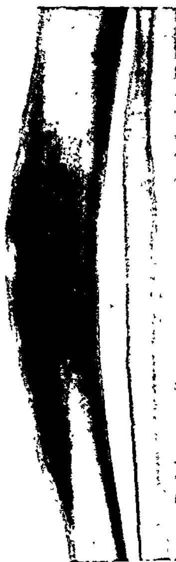


Fig 291 Gummatous osteitis of the tibia

## Adults

**Gummatous Osteitis.** There are several forms :—

(*a*) Localized Gummata of the long bones, commonly the clavicle or tibia. There is a central area of destruction surrounded by a diffuse zone of sclerosis. There may be periosteal bone formation and thickening of the whole bone (Fig. 291).

(*b*) Diffuse Gummatous Infiltration of the long bones. There is a general osteoporosis with many areas of trabecular destruction.

(*c*) Syphilitic Dactylitis commences in the medullary region of the metacarpals, metatarsals or phalanges. There is rather more sclerosis and new bone formation than in tuberculous dactylitis which it otherwise resembles (p. 346).

(*d*) Gummatous Periostitis is found in the sternum, clavicle, ribs, and sometimes in the long bones. When it occurs at a subcutaneous surface, an indurated, red swelling is formed that bursts through the skin to form a typical gummatous ulcer.

## ACUTE SUPPURATIVE ARTHRITIS

The synovial fluid has a bactericidal action and there is no good reason to believe that joints are more susceptible to infection than other parts of the body, or that their resistance is lower. The result of unchecked suppuration in a joint is, however, more serious than elsewhere because it causes gross interference with function.

Infection can reach a joint in the following ways :—

1. By the blood stream.
2. By direct spread from a neighbouring focus of infection, usually in bone.
3. By penetrating wounds.

Frank suppuration is usually due to staphylococcal or streptococcal infection although it may be caused by almost any other micro-organism. Blood borne infection originates in a manner similar to acute hæmatogenous osteomyelitis, the bacteria being derived from a superficial focus such as a boil or an infected tonsil. It may occur at any age but is commonest during childhood and adolescence. Acute suppurative arthritis of infancy, which usually affects the hip joint, is described on p. 122.

### Pathology

The synovial membrane becomes acutely inflamed and there is an effusion into the joint which at first is only turbid. If the diagnosis is made promptly, it may be possible to control the infection at this stage and resolution takes place leaving a normal joint. In the absence of treatment the effusion rapidly becomes thick and purulent, and if suppuration is allowed to continue, granulation tissue is formed which spreads over the surface of the articular cartilage gradually eroding and destroying it. When the cartilage has been perforated the infection spreads to the epiphysis causing osteomyelitis, and it may also perforate the joint capsule and track into the surrounding soft tissues.

Restriction of movement is an inevitable sequel to prolonged suppuration. The granulations on the opposing surfaces of the joint fuse together and are converted into fibrous tissue (Fig. 292). If the articular cartilage has been destroyed exposing cancellous bone, the fibrous tissue ossifies and the result is bony ankylosis. Destruction of bone and soft tissues, or gross distension of the capsule, may be followed by pathological subluxation or dislocation ; this often occurs in suppurative arthritis of the hip in infants.

### Signs and Symptoms

The onset is accompanied by general toxæmia which becomes more profound as pyarthrosis develops. There is a high swinging temperature characteristic of a closed abscess, and the joint is painful, hot and distended. The point of maximum tenderness is over the joint, and not over the epiphysial line as in acute osteomyelitis. The joint is held in the position of greatest ease, usually semiflexion. At an early stage there is a limited

range of passive movement, but after the articular cartilage is covered with pannus, the limb is held rigid and attempted movement causes intense pain—even shaking the bed may be so painful that the patient is apprehensive when anyone approaches.



FIG 292 Chronic suppurative arthritis of the hip followed by fibrous ankylosis Treatment commenced late, twelve days after onset

Diagnosis has to be made from acute osteomyelitis and acute rheumatism. In acute osteomyelitis the temperature is more often sustained than swinging, tenderness is localized to the epiphysial line, and there is a considerable range of passive movements provided examination is sufficiently gentle. Acute rheumatism seldom, if ever, remains monarticular for longer than a day or two. Time must not be wasted by awaiting the result of laboratory examination of the fluid, or the response to the administration of salicylates. When suppurative arthritis is suspected the joint must immediately be aspirated, and if the fluid is cloudy or turbid on naked eye inspection, treatment is commenced at once.

## Treatment

Penicillin, as with other acute suppurative conditions, has revolutionized treatment. The prognosis as regards movement depends chiefly

on preventing gross suppuration and it is of utmost import to commence treatment at the earliest moment.

The joint is aspirated and the fluid inspected. If it appears cloudy or turbid, a solution of penicillin should be instilled in its place. (It is undesirable to introduce penicillin unnecessarily into an uninfected joint because this has occasionally resulted in infection by a penicillin-resistant organism). Systematic penicillin is also given to control the primary source of infection and deal with any local spread around the joint that may have occurred. The affected joint should be immobilized; the knee or elbow may be enclosed in a bi-valved plaster-of-Paris cast, the hip requires extension with the leg in a Thomas's splint, and the shoulder is supported on an abduction splint.

The quantity of penicillin introduced into the joint is ordinarily 100,000 units in 5 ccs. of water. The injection should be repeated every forty-eight hours until the infection has been controlled as determined by bacteriological examination of the aspirated fluid. This is unlikely to take longer than a week although a small sterile effusion may remain for a considerable time, and a slightly raised temperature may persist for as long as the administration of penicillin is continued. The joint should be kept at rest for at least a week after the fluid has become sterile.

When treatment has been delayed until suppuration is well advanced, the pus may be too thick to aspirate. Operation is then necessary. The joint is opened by a lateral incision and thoroughly washed out with a copious quantity of saline; penicillin is introduced and the synovial membrane sutured, but the superficial layers of the wound are left open for later closure. Very advanced infection requires extensive drainage. The knee is always difficult to drain satisfactorily because of its many recesses; it is perhaps managed best by making two lateral incisions and nursing the patient face downwards.

### Arthritis in Pneumonia and Zymotic Diseases

Joint infection sometimes occurs during the course of pneumonia, enteric fever, dysentery, scarlet fever and other exanthemata. The infection may be due to the specific organism of the disease or to associated infection by streptococci or bacillus coli.

**Pneumococcal Arthritis.** This occurs very occasionally during the course of lobar pneumonia, usually about the tenth day, and it is also seen in children, but not in adults, as a primary joint infection without clinical evidence of infection of the respiratory tract. The severity of the infection ranges from a mild serous synovitis to suppurative pyarthrosis. Complete recovery was the rule before the use of penicillin, and with penicillin the prognosis should be excellent.

**Scarlatinal Arthritis.** An effusion into one or more joints is not uncommon during the first week or ten days of scarlet fever. It is probably toxic in origin and usually clears up quickly without treatment. At a later stage of the fever there is very occasionally a gross streptococcal infection of a joint.

## Gonococcal Arthritis

This is a mild form of suppurative arthritis. It occurs in 1 per cent to 2 per cent of patients with established urethritis, but since so many acute infections are now rapidly controlled by chemotherapy this represents a *very small fraction of them all. When arthritis* has complicated one attack of urethritis, it often recurs with a second attack.

The condition is usually polyarticular and any joints may be involved; the commonest are the knee, ankle, metatarso-phalangeal, wrist, metacarpo-phalangeal and interphalangeal joints in that order of frequency. Occasionally only one joint is infected, usually a large joint and one that is much used, for example the knee or ankle, and in coal-miners the elbow and wrist; it is then usual for suppuration to be more severe, the fluid aspirated from the joint is obviously purulent and gonococci are readily recovered from it.

The onset is usually between one and three weeks of the development of acute urethritis, but sometimes later, and occasionally much later. The course may be acute, subacute or chronic. The acute form is accompanied by pyrexia of 100°-102°, and the white cell count rises to between 30,000 and 40,000. There is severe pain, the joints are distended with fluid, they are red, hot and tender, and there may be overlying subcutaneous œdema. The more chronic forms are not accompanied by such marked constitutional disturbances, but there may be some leukocytosis; the characteristic feature is a polyarthritis with much pain and gross effusion into the larger joints.

The X-rays show only soft tissue changes unless destruction of articular cartilage is sufficiently advanced for the joint space to be narrowed.

The diagnosis is obvious in the typical case in which acute urethritis is followed in a few weeks by polyarthritis with marked effusion into the joints. In chronic cases, particularly if monarticular, and if venereal infection is denied, diagnosis may be difficult. The synovial fluid contains an excess of cells but gonococci are seldom demonstrable, even by culture. The compliment fixation test is positive in a high percentage of infections.

### Treatment

The response to penicillin and sulpha preparations is usually excellent, and if treatment is commenced early, resolution takes place without damage to the joint. In neglected infections, the articular cartilage may be destroyed and fibrous ankylosis occurs; *bony ankylosis is uncommon.* Occasionally infection is due to a strain of organisms resistant to chemotherapy, and then hyperthermy may be worth a trial.

## CHAPTER XI

# TUBERCULOSIS

TUBERCLE bacilli are scattered throughout the world in great numbers and large sections of the population at some period in their lives suffer from sub-clinical infection. Only a proportion, however, develop overt tuberculosis and this is favoured by exposure to an excessively large dose of bacilli, and by a low resistance to disease. The risk of exposure to direct infection by human beings suffering from tuberculosis is a major medico-social problem that has not yet been solved. Exposure to infection by infected milk and food can be controlled; in some countries this has already been achieved, but Great Britain is backward in this respect and much unnecessary suffering is caused, and many lives are unnecessarily lost, because there is no proper standard of public hygiene. Individual resistance to tuberculous infection is also controllable to some extent because tuberculosis is a social disease, and although it does occur in all classes, the incidence is greater amongst poorer people. Bad housing and overcrowding increase exposure to infection, undernutrition reduces bodily resistance, and unemployment leads to both overcrowding and under-nutrition.

Tubercle bacilli are of two types, human and bovine, the former being responsible for about two-thirds or three-quarters of all bone and joint infections. The human type enters the body by inhalation or ingestion, whilst the bovine type is usually consumed in milk or butter obtained from diseased cattle. In both instances the bacilli pass to the tonsils and to the mesenteric and bronchial glands where small abscesses are formed; from time to time bacilli are liberated into the blood stream from these abscesses.

Bones and joints are never the seat of primary tuberculous infection. Bacilli always reach them from some other focus in the body via the blood stream, and perhaps occasionally via the lymphatic system. The primary focus may be a small abscess in a lymphatic gland which is not itself causing symptoms and which cannot be located by existing methods of examination, but often it is large enough to cause symptoms and its presence can be detected. It is likely that the development of tuberculosis in bone is determined by local injury or some other condition which so devitalizes the tissues as to form a suitable medium for the culture of organisms deposited in them.

In a majority of patients the initial infection is near a joint and both bone and joint are involved (tuberculous arthritis), but occasionally a flat bone or the shaft of a long bone, for example a rib, is affected (tuberculous osteitis). The pathological process is similar in both cases, but the symptoms and course are somewhat different.

## TUBERCULOUS ARTHRITIS

Tuberculous arthritis is essentially a disease of childhood; the maximum incidence is between three and five years of age and about 80 per cent of cases are in children under fourteen. In childhood the joints *most commonly affected in order of frequency are the vertebræ, the hips* and the knees. In adults the knee is the commonest joint to be involved; disease of the upper limbs is relatively commoner than in children but it accounts for a minority of infections.

### Pathology

The general behaviour of tuberculous infection in bone is similar to that in other structures. There is a stage of invasion, a stage of activity, and a stage of regression and repair.

**Invasion.** The infection usually commences in the subchondral bone near the periphery of a joint, and sometimes in the metaphysis close to the epiphysial line. The precise position varies with the individual bone and probably depends on the arrangement of the blood supply and the liability to trauma. A focus near a joint is seldom restricted to bone and almost invariably spreads to the joint within a short time. There is some controversy as to whether synovial membrane is at times infected before bone but the matter is of no great clinical importance. By the time so-called synovial tuberculosis has given rise to symptoms, there is histological evidence that both bone and synovia are involved.

**Activity.** Tubercle bacilli, having been deposited in the bone at a spot suitable for growth, multiply and form tuberculous giant cell systems; these coalesce and increase in size destroying and replacing normal tissues. The tuberculous nodule thus formed is avascular so the centre degenerates and becomes necrotic, but the periphery continues to expand. The surface of the bone is soon perforated and the joint exposed; there is then rapid dissemination and the whole synovial membrane and articular cartilage become covered with tuberculous granulation tissue. The articular cartilage *is eroded allowing yet more extensive invasion of the underlying bone and* both bone and joint are progressively destroyed and replaced by tuberculous material. The tissues over a large area become œdematous, possibly accounting for the widespread rarefaction of bone (Plate I, p. 104).

Abscess Formation. A *tuberculous abscess (cold abscess) is formed* when the surface of the bone or the joint capsule is perforated and tuberculous material passes outside. It tracks along the planes between muscles or within muscle sheaths as determined by the disposition of the deep *fascia (Fig. 294, and Fig. 77, p. 104). The abscess is confined by the* fascia but may perforate it when the tension rises by reason of the great volume of fluid produced, or the restricted space available. After perforating the deep fascia the abscess be[illegible]
the *overlying skin gives* w[illegible]
communicates with the joint [illegible]
is inevitable.

The walls of the abscess are composed of thick fibrous tissue. Its contents consist of serum containing degenerate white cells and the liquified products of the tissues that have been destroyed. Tubercle bacilli are usually present although they are not easy to demonstrate. The great quantity of fluid produced in some tuberculous joints has not been satisfactorily explained; as much as a pint a week has been removed regularly from a single abscess.

**Repair.** Tuberculous arthritis, like tuberculosis elsewhere, tends to run a course lasting some years but it is doubtful if it can be greatly shortened by treatment. As the disease regresses, such bony tissue as




FIG 293 Fibrous ankylosis of the hip following tuberculous arthritis

remains recalcifies and its intimate structure returns more or less to normal. Tuberculous granulation tissue is converted into fibrous tissue, but active tubercles may be encapsulated in it and remain there quiescent more or less indefinitely. These tubercles contain living bacilli which can cause recrudescence of the disease, even years later, if they are liberated as the result of injury to the encapsulating fibrous tissue.

Since repair is by fibrous tissue, the ultimate result in most cases is fibrous ankylosis of the joint (Fig. 293). In some regions, particularly the spine, very slow ossification of the fibrous tissue may take place over a

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t[illegible]
communicates with the joint and secondary infection by pyogenic bacteria is inevitable.

**Swelling.** The synovial membrane and periarticular tissues are thickened, and the joint is distended with tuberculous material. The more superficial joints like the knee acquire a typical "boggy" feeling, but the spine and hips are too deeply placed for accurate palpation.

**Wasting.** The muscles waste rapidly and sometimes to an extreme extent. All muscle groups acting on the infected joint are involved. The wasting accentuates the appearance of swelling and makes it seem greater than it really is.

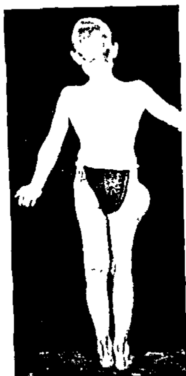


FIG 294 Tuberculous abscess of the hip



FIG 295 Sinuses communicating with a tuberculous hip

**Abscess.** A swelling is occasionally the first sign of disease to be noticed and this may cause some difficulty in diagnosis. Abscesses connected with the hip and spine are often large, and usually cold and painless (Fig. 294). Abscesses from smaller joints have not the same opportunity to track along tissue planes and they more readily perforate the skin.

**Sinuses.** These may form spontaneously when an abscess perforates the skin, or they may follow surgical intervention. The typical tuberculous sinus has a flat, blue-coloured edge surrounded by atrophic skin and is very indolent (*Fig. 295*). The scars of multiple sinuses are a conspicuous feature of healed tuberculous disease and they may reveal the nature of the original diagnosis many years later.

period of years, but as a rule bony ankylosis occurs only when there has been secondary infection. Fibrous ankylosis is an unstable state liable to yield to excessive strain, and since the fibrous tissue may contain encapsulated foci of living bacilli, the condition cannot be said to represent "cure" in the ordinary sense of the word.

During the process of repair the fluid content of an abscess, if there has been no sinus for it to drain through, is slowly absorbed leaving an inspisated mass which shrinks towards the affected joint. The residue becomes fibrosed and calcified in an irregular manner giving a characteristic radiological appearance.

### Signs and Symptoms

The early indications of joint disease are pain, spasm and limitation of movement. These findings are not diagnostic of tuberculosis, but they are indicative of some irritative condition of the joint and must be regarded as a danger signal which, especially in children, should never be ignored. In every instance investigation must be pursued until the cause has been determined.

**Pain.** This is usually an early and prominent symptom. It occurs after involvement of the synovial membrane or articular cartilage and is associated chiefly with movement, being reduced or abolished when movement is restricted by muscle spasm. Sometimes pain is absent throughout the whole course of the disease, and often there is no real pain, but an ache which is worse towards the end of the day or after exercise and is relieved by rest. The onset of pain often follows a minor injury that forces movement beyond the limit set by the muscles. The so-called "night-start" due to relaxation of protective spasm during sleep is not an early sign but a late one, and not very common at that.

Pain is not necessarily localized to the affected joint and is often referred to a distant point that has a nerve supply derived from the same spinal segment. For example, earache may be the first complaint when there is upper cervical caries, and pain in the knee is very common in disease of the hip.

**Spasm and Limitation of Movement.** Spasm of the muscles controlling the joint is an early and constant sign. Both active and passive movements are restricted, at first perhaps only to a slight extent. Movement may be quite free over part of the range but it is suddenly checked by the muscles, and if the attempt is made to continue the movement beyond this limit, the bone proximal to the joint is moved instead. The patient is apprehensive of any attempt to use force.

**Limp.** This is a characteristic symptom in disease of the lower limb or spine and is often the first abnormality noticed. In spinal disease limp is caused by irritation of the psoas muscle which produces a flexion deformity at the hip. Unexplained limp in a child, even if painless, is an imperative indication for complete examination.

**Deformity.** There is nearly always some deformity. The position of the joint is determined by the constant pull of the stronger muscle groups and, at a later stage, by actual destruction of the bone.

## X-ray Appearances

Tuberculous arthritis may be present before there is any radiographic evidence of disease and therefore a negative examination shortly after the onset of symptoms does not exclude it. If symptoms persist, further X-rays should be taken at intervals of two to three weeks. Films of the highest quality, preferably stereoscopic, are essential or early changes in the detail of bone structure will not be shown.

The typical changes are (Fig. 296) :—

TRABECULAR DESTRUCTION. The initial focus in bone is not always demonstrable but it may be possible to detect in the juxta-articular or juxta epiphysial region a localized area from which the normal trabecular structure has disappeared. There may be several such areas that later coalesce.

NARROWING OF JOINT SPACE. As the articular cartilage is destroyed, the size of the joint space decreases.

LOSS OF OUTLINE. Erosion of the articular surface of the bone makes the outline of the joint irregular and sometimes fluffy.

GENERAL DECALCIFICATION. There is frequently widespread decalcification of all the bones forming the joint and extending for a distance of an inch or two from it. The margin of this area is sharply defined.

DESTRUCTION OF BONE. As the disease progresses, there is an increasing amount of bone destruction.

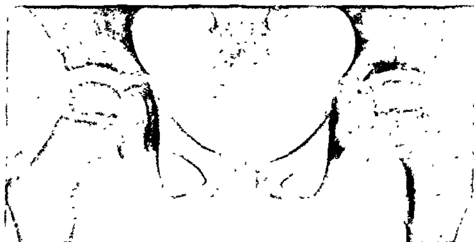
ABSCESS. A paravertebral or a psoas abscess is nearly always present in spinal disease at a very early stage and is clearly visible in good films (Fig. 77, p. 104).

## Diagnosis

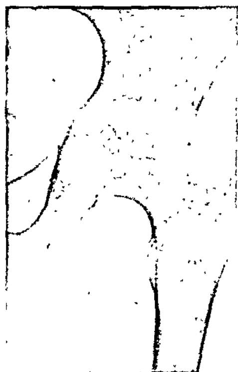
In children the clinical signs of irritation of a joint—pain, spasm and limitation of movement—when accompanied by radiological evidence of destruction of bone are sufficient evidence on which to base a diagnosis. When the X-rays are negative, the child should be put to bed and kept there until the symptoms disappear or X-ray changes appear. There is occasionally difficulty, particularly at the knee, when the infection is principally synovial and there is not sufficient destruction of bone to be demonstrable radiologically. The following special tests may then be helpful :—

**Aspiration.** This is a permissible method of obtaining material from a suspected joint for laboratory examination, and one of the more valuable ancillary aids to diagnosis, but the findings in active disease are by no means always positive. A full aseptic technique is essential. The needle should enter through healthy skin, the track must be as long as possible and, if practicable, pass through muscle ; the skin is pulled sideways before perforating the deep fascia to act as a valve.

**Biopsy of Lymph Glands.** The *inguinal* lymph glands provide histological evidence of tuberculosis in a high percentage of infections of the joints of the lower limb (Seddon).



*February*, 1945 Narrowing of joint space, irregularity in outline of the head of the femur and general rarefaction



*November*, 1945 Increasing destruction of bone



*July*, 1947 Recalcification An area of sclerosis is forming around the acetabulum

FIG. 296 Tuberculous arthritis of the hip

favourable conditions for all patients with bone and joint tuberculosis, including those requiring operative treatment. So far as children are concerned, a great majority in Great Britain are treated in suitable circumstances. The position as regards adults is less satisfactory; not only are there insufficient properly equipped institutions, but the wage earner or the mother of a family will press for any alternative rather than face many months in hospital. There has, therefore, been a tendency to neglect the general treatment of adults in favour of radical surgical methods, but the modern trend is towards providing adults with the same advantages as children.

The regime in an open-air hospital has the same general principles whether the infection is of the bones and joints, or of the lungs. The chief indications are rest, food, air and sun, and the greatest of these is rest. Rest for the joint must be continued until the diseased tissues have healed; but before this has occurred, the patient's general condition may have progressed to an extent that makes exercise for the rest of the body desirable. This is practicable with disease of the upper limb which can be splinted satisfactorily whilst the patient is ambulant. With disease of the lower limb and spine, however, recumbency has to be continued for much longer, and the length of stay in hospital for children is often about three years.

**Local Treatment.** This may be

(*a*) *Conservative.*
(*b*) *Operative.*

Conservative Treatment is directed to the provision of rest for the joint in the best functional position until healing has occurred. The method of fixation varies with the individual joint but there are certain general requirements :—

1. Complete immobility of the joint.
2. Fixation in the position giving the best function for the ankylosed joint.
3. The apparatus should permit of easy inspection to detect abscess formation.
4. The joint surfaces during th[illegible] active stage usually should be kept apart [illegible] being distorted by the pressure of the [illegible]
5. The joint surfaces during the stage of regression should be allowed to come together to facilitate consolidation.
6. Fixation must be continued until the disease is quiescent and consolidation well advanced.
7. After the period of recumbency, it is usually necessary to protect the joint by mechanical or operative methods until there is secure ankylosis. The occasions when a useful range of movement remains and can safely be permitted are few.

Operation. Opinion has fluctuated at different times and in different countries between early radical operation and the complete denial of the

**Tuberculin Reaction.** The Mantoux reaction is probably the most reliable tuberculin test and a positive reaction to a concentration of one in ten thousand is usually held to be diagnostic of active tuberculosis. The reaction may, of course, be due to disease elsewhere than at the suspected joint, and over five years of age it is frequently positive in the absence of clinical evidence of tuberculosis. It is occasionally negative even when there is active disease of bone.

**Temperature.** There is often a rise of 1° to 3° in body temperature, usually during the afternoon, with active tuberculosis. As the duration of the rise may be short, the temperature should be taken every hour for several days. Thermometers should be checked against each other, or the same one used all the time.

**The Sedimentation Rate** is usually, but not invariably, raised in active tuberculosis, but it is also raised, especially in adults, with other types of arthritis likely to cause difficulty in diagnosis.

**Arthrotomy** for diagnostic purposes is seldom necessary, and it is an undesirable proceeding because a sinus may form in the scar even when the wound heals by first intention. Biopsy is never practised in children when tuberculosis is suspected, and in adults only when it is proposed to follow a positive finding with excision and arthrodesis of the joint or with amputation.

### Treatment

Healing of a tuberculous lesion depends less upon the skill of the physician than the natural forces of the patient. Our principal duty is to assist the patient to combat the disease by providing him with the best conditions as regards both general environment and the affected joint. Treatment does not end with apparent healing of the lesion and it is essential to arrange for regular, skilled observation until it is certain that permanent consolidation has occurred. And when nature's methods alone fail to give sufficient security, as often happens, protection by mechanical or operative means may be necessary.

Provision for treatment of every patient with tuberculous arthritis should be made under each of the following headings :—

A. Active Disease.
   1. *General environment.*
   2. *Local treatment of the joint.*

B. "Healed" Disease.
   1. *Mechanical or operative protection for the joint.*
   2. *Regular examination over a prolonged period.*

**General Treatment.** There are two important reasons why tuberculous arthritis should receive general treatment as well as local. Firstly to increase the general resistance, and secondly for the benefit of associated lesions because there must always be a primary focus elsewhere. Associated pulmonary disease has been detected in about 50 per cent of patients, the exact figure varying with the methods of investigation used.

Institutional treatment in an open-air country hospital offers the most

is seldom achieved because of the difficulty in removing all infected tissues.

5. Certain types of operation are performed with the intention of stimula-

osteotomy of the femur is an e



Fig 298 Arthrodesis of the hip by Brittain's method in a patient with tuberculous disease (by courtesy of Prof H J. Seddon)

6. Drainage of an abscess, usually mediastinal, may only be possible by open operation.
7. Amputation is not infrequently the most desirable course with disease of the foot or knee, particularly in adults. It may be necessary as a life-saving measure in fulminating infections in both children and adults.

**Protection after Healing.** Early. There is a period after the patient is ambulant, but before the greatest amount of consolidation has taken place, during which protection of the joint is essential. This is provided by means of apparatus, for example a spinal brace or a weight-relieving caliper.

value of surgery, and there is still no general agreement. Conservative treatment is the rule in Great Britain and a decision to operate is made only when the general and local conditions favour it, or when there is an urgent indication for interference. In the United States of America arthrodesis is performed at many clinics during the active stage as a routine procedure; it is, however, regarded by those surgeons who advocate it, with but few exceptions, as ancillary to general treatment, and not as a substitute.



FIG 297 Tuberculous focus in the neck of the femur; the joint is also involved

The following procedures may be required *during the active stage* in some circumstances:—

1. Excision of an extra-articular focus is very desirable when practicable, but it is seldom possible because the joint is nearly always infected at almost the same time as the bone. Even when X-rays suggest the contrary, there is frequently a communication between a focus in bone and the joint (Fig. 297).
2. Excision of the joint has as its purpose the eradication of all disease. It has no part in the treatment of tuberculosis in children. In adults it may be tempting to try to shorten the period of treatment by excision but the results are not encouraging unless there has first been adequate conservative treatment. The best time for surgical intervention is when the patient's general resistance is at its greatest and the local lesion is beginning to regress.
3. Arthrodesis is the most efficient method of ensuring immobility of the diseased joint and it is a usual procedure during the active stage at many clinics in the United States of America, but not at all. In Great Br[illegible] the disease is quiescent bec[illegible]me and this is thought to del[illegible] recurrence.
4. Synovectomy is sometimes performed when the disease appears to be restricted to soft tissues. The object is to preserve movement but this

**Tuberculous osteitis.** The classical example is tuberculous dactylitis which is described on p. 346.

**Tuberculous Periostitis.** This is exemplified by infection of the ribs (Fig. 299). The infection may be blood-borne, or it may spread from a cold abscess that has tracked from the spine along an intercostal space. The disease spreads over the surface of the rib deep to the periosteum, and it may follow the perforating vessels through the cortex of the bone. The surface of the rib is eroded, an abscess rapidly forms, and unless treatment is prompt, the overlying skin gives way leaving a sinus, or the abscess tracks inwards and infects the pleura.

It is sometimes possible to excise completely the infected portion of rib and the abscess, but general treatment is essential whether this can be done or not.

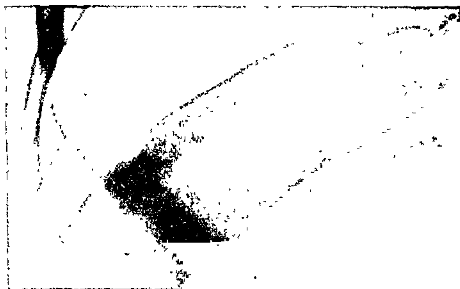


*Fig* 299 *Tuberculous osteitis of a rib* There was no recurrence four years after resection

LATE. *After healing is complete and the condition has become static,* it is tempting to stop the use of protective apparatus. It is doubtful if this is wise. Healing usually takes place by fibrosis, and since living tubercle bacilli may be encapsulated in the fibrous tissue, any undue strain on the joint is likely to result in the liberation of bacilli and recrudescence of the disease; moreover deformity may gradually develop at a joint such as the hip when there is only fibrous ankylosis. No joint without bony ankylosis can be regarded as secure (except on the rare occasions when there is free movement after it has healed).

[illegible]

of the lower limb which are necessarily exposed to many stresses in the ordinary course of life. Apparatus is most irksome, and since few patients tolerate it indefinitely, the question of arthrodesis usually arises sooner or later.

Arthrodesis is of undoubted value when the disease is quiescent. This is particularly so at the spine, the hip and the shoulder which can be fixed by an extra-articular method (Fig. 298), but there is some reason to hesitate before operating on the knee or ankle where it is necessary to open the diseased area. The best time for arthrodesis is when the patient has withstood the clinical test of living in normal conditions wearing protective apparatus for two or three years without any reactivation of the disease. The subject is further discussed in the chapters dealing with individual joints.

**Follow-up.** This aspect of treatment is often overlooked but it is important both for the welfare of the patient and for accurate assessment of different methods of treatment that regular examination is carried out over a very prolonged period. It should be arranged whenever possible by *the team responsible for the original treatment and with full records* available at the time. The investigation should include not only the patient's general health and the physical condition of the diseased joint, but also his home circumstances and conditions of work. Those who have once suffered from clinical tuberculosis are more likely to do so again than is the rest of the population, and therefore it is important to ensure that they remain in a satisfactory environment.

## TUBERCULOUS OSTEITIS

There are certain positions at which tuberculous infection is primarily an osteitis or periostitis and joint involvement is unusual. The commonest sites are the fingers and ribs, the sternum is occasionally affected, and the mastoid may be involved secondarily to middle ear disease; infection of nearly every other bone has been described on rare occasions. The process is *essentially the same as in tuberculous arthritis; the mode of infection* and the pathological changes are similar, but because of difference in structure and function, the symptoms and course are somewhat different.

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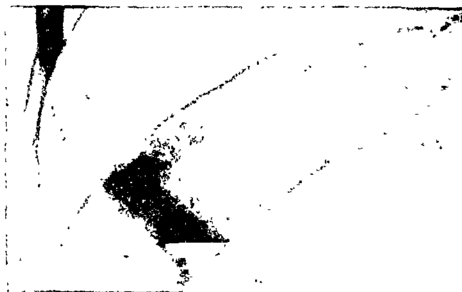


Fig 299 Tuberculous osteitis of a rib There was no recurrence four years after resection

CHAPTER XII

# CHRONIC ARTHRITIS

Attempts to classify chronic arthritis are gravely handicapped by the vagueness of our conceptions as to the ætiology, and by the difficulty of interpreting the histological material. Although the terminology has become so diverse as to deny understanding to all but the professional rheumatologist, comparatively little real progress has been made during centuries except to separate as clinical entities arthritis due to metabolic diseases such as gout, and specific infections like gonorrhœa. There seems, therefore, to be no advantage, in our present state of knowledge, in departing from the time-honoured classification introduced many years ago by the Garrods —rheumatoid arthritis and osteoarthritis. These terms correspond closely with atrophic and hypertrophic arthritis of American usage.

The following simplified statement of the position has the merit both of being comprehensible and of providing a practical working basis for investigation and therapy. More elaborate accounts are apt to lose in clarity as they increase in detail.

The author accepts the view that osteoarthritis is essentially a process resulting from damage to the articular cartilage. The cartilage provides a delicate bearing surface somewhat resembling a white-metal bearing in a motor-car engine, and if the congruity of the surface is disturbed, the bearing ceases to run true and it soon wears out. Damage to the cartilage [illegible] of the joint, or disease; rheumatoid [illegible]t may damage the cartilage, thus [illegible] of some cases of osteoarthritis.

Rheumatoid arthritis, on the other hand, appears to be a specific disease process, or possibly a whole series of diseases of different ætiology. The course varies according to the severity of the attack, the resistance of the patient, and the age. The response of the tissues at different ages may well be one of the major factors determining the course. In children the disease is usually acute and is accompanied by fever and general involvement of lymphatic tissues; in early middle-age it tends to be less acute and the classical rheumatoid picture is seen; in later life the tissue reaction is yet slower and therefore the opportunity for mechanical factors to be superimposed is greater.

Rheumatoid arthritis and osteoarthritis, although often pursuing distinct and typical courses, are not always clear cut entities, either clinically or pathologically; many cases are atypical, and sometimes the two conditions are superimposed and the pathological picture is confused.

## RHEUMATOID ARTHRITIS

(*Synonyms*) Atrophic Arthritis, Proliferative Arthritis, Ankylosing Arthritis, Arthritis Deformans

### Ætiology

Little definite is known about the ætiology of rheumatoid arthritis although, as one of the greatest scourges of mankind, it has given rise to a deal of speculation. The tragic consequences of the disease, and the relative impotence of the medical profession when treating it, have fostered the growth of "cures" of all types and driven the unfortunate sufferers into the willing hands of every kind of qualified and unqualified "therapist." Most theories as to the ætiology are speculative and are based on the results, and even the apparent results, of treatment. But since the course in a particular patient is unpredictable, since benefit may follow any treatment that is lavish of personal care and sympathy, and since hope springs eternal, statistics have not always the significance that their authors attach to them and definite conclusions can seldom be drawn.

Rheumatoid arthritis is essentially a disease of the first half of life and has a maximum incidence in early middle age. Women are affected rather more than twice as frequently as men. Heredity stands out prominently as an ætiological factor and different investigators have found a familial association, if collateral branches of the family are taken into account, in the region of fifty per cent. There is, however, no information as to the nature of the transmitted factor or, indeed, if it is a physical attribute that is inherited, and not an environment.

The possibility of a psychological factor being concerned in the ætiology is suggested by the frequency with which the onset of symptoms corresponds with a period of mental anxiety, or with physical fatigue which may itself be associated with anxiety. It is probable that the sympathetic nervous system is involved because there are often changes in the blood supply of the skin.

Focal infection has been the attractive subject of many investigations during the last twenty-five years, chiefly in the United States and to a lesser extent in Europe, because of the opportunity it offers for positive therapy. The position, however, is still far from clear. Painstaking research has shown that foci of chronic infection are as common amongst the general hospital population as amongst arthritics, and they are probably no less frequent amongst the "healthy" population at large. But although focal infection does not necessarily stand in direct causal relationship to arthritis, the accumulated evidence of the beneficial results that sometimes follow the elimination of undoubted foci cannot be disregarded. Surgical removal of a focus may benefit one patient but have no effect on another, even when the strain of bacteria is identical, and the effect in a particular instance can only be discovered by trial.

The teeth and tonsils are the most likely sites to harbour infection. The tonsils are perhaps commoner offenders in younger people, whilst

pyorrhœa and apical abscesses are more frequent in middle age. The nasal sinuses and other parts of the upper respiratory tract are sometimes incriminated, and occasionally infection of the genito-urinary tract in men and chronic cervicitis in women appear to be causal factors. The gastro-intestinal and biliary tracts are sometimes looked upon with suspicion, particularly in visceroptotic patients.

Almost any kind of micro-organism may be found in a focus of infection, but streptococci and staphylococci in all their varieties and strains occur with greatest frequency. Some workers have gone so far as to regard a particular sub-strain which they happen to have isolated from a number of arthritic patients as the cause of arthritis in general, but such claims have never been confirmed.

An attractive explanation of the way in which focal infection influences joints is that the break-down products of the inflammatory process stimulate the formation of an antigen to which the joints become sensitized. There is no real evidence to support the theory but it is in keeping with the reaction of joints in known allergic conditions.

## Pathology

The two types of arthritis remain more or less distinct, but mixed types showing either osteoarthritic changes superimposed on predominantly rheumatoid disease, or osteoarthritis accompanied by soft tissue proliferation are not uncommon. The typical changes in rheumatoid arthritis (Plate V) are :—

**Synovial Membrane.** The process begins in the synovial membrane which proliferates and thickens. The inner surface becomes rough and granular, and later is heaped up into ridges and fringes. The latter may grow to a considerable length and float free in the joint like the tentacles of a sea-anemone in a rock pool (*villous proliferation*). Such a fringe is liable to be nipped between the bones and cause acute symptoms. A "pannus" which appears to be derived from the synovial membrane spreads slowly over the articular cartilage. The pannus is at first very vascular, but later it is converted into fibrous tissue.

**Joint Capsule.** The capsule proliferates and becomes a mass of dense fibrous tissue. The new tissue contracts and restricts movement of the joint.

**The Articular Cartilage.** This is involved rather late. The changes are degenerative and are probably due to interference with its nutrition caused by the spread of pannus, and perhaps by fibrosis of the underlying bone. The cartilage loses its smooth, shiny appearance and changes to a dusky grey ; it becomes gradually thinner and finally disappears. The bone thus exposed is not eburnated, as in osteoarthritis, but remains cancellous. Erosion of the cartilage is often patchy, and when areas of erosion on the opposing surfaces of the joint are in corresponding positions, granulation tissue spreads between them ; the granulations are later converted into fibrous tissue producing fibrous ankylosis, and if ossification occurs, bony ankylosis.

PLATE V



Rheumatoid Arthritis of the Knee

[*To face page* 388

**Bone.** Decalification of bone near the affected joints begins at an early stage. Later there is trabecular absorption which is possibly due to connective tissue proliferation in the marrow spaces (Nichols and Richardson).

**Muscles.** There is rapid and often severe atrophy of the muscles surrounding the joint. After a time fibrous tissue proliferates between the muscle fibres and eventually destroys them. This seriously affects the possibility of a return of active movements, even if passive movement at the joint can be restored by operation or otherwise.

**Skin.** There are usually atrophic changes around the joints, and small nodules are often formed in the subcutaneous tissues, particularly of the fingers. These nodules consist of vascular connective tissue, usually partly degenerate.

**Physiological Disturbances.** Many have been described, but none are constantly present. The blood chemistry has been investigated in great detail but no alteration of significance has been found in the concentration of any of the mineral salts or amino-acids. In view of the popular ideas about a meat diet, it is noteworthy that no disturbance has been detected in the metabolism of nitrogen, or in the acid-base equilibrium of the blood. Blood phosphatase is not raised. The blood serum shows no constant change in agglutinins, antifibrolysin titre or precipitin reaction. Hepatic and renal function are unaltered.

There is reliable evidence that the basal metabolic rate is sometimes lowered and the sugar tolerance reduced, but it is probable that both are connected with circulatory changes and are not due to a specific alteration in tissue metabolism. The erythrocyte sedimentation rate is constantly raised during the active stage and this is of some value as an indication of the progress of the disease.

## Clinical Features

Rheumatoid arthritis is seldom monarticular, even to start with, and it is commonly of symmetrical distribution. The onset is usually insidious although occasionally it is fulminating and may be mistaken for rheumatic fever. It begins most often in the hands and feet and spreads centrally up the limbs to involve the larger joints. The order of frequency with which the joints of the limbs are affected when the disease is fully developed is fingers, knees, elbows, tarsus, shoulders, hips.

At first there may be only a little pain, tenderness and stiffness in the affected joints lasting for a short time. There may be several such attacks before swelling is first noticed, but as the disease is established, swelling of the joints becomes marked and the muscles atrophy, sometimes to an extreme degree. Pain and tenderness are severe, and muscle spasm prevents almost all movement. The skin becomes atrophic, and looks [illegible] T[illegible] may be brittle and discoloured. Subcutaneous [illegible] n fingers and elsewhere. Sweating is free [illegible] the hands and soles of the feet, and the sweat often has a characteristic odour.

The swollen joints may be slightly red and hot, and the skin seems tightly stretched over them. There is usually some effusion, although this is more obvious in the larger joints than the smaller. The joints have a typical fusiform, spindle-shaped appearance which is most marked in the fingers (Fig. 300). Swelling of the large joints is accentuated in appearance by muscle wasting. Flexion deformities develop rapidly; they are most difficult to correct, and unless the utmost care is taken with splinting, the joints may dislocate or subluxate. In an established case the deformity



*Fig 300 Rheumatoid arthritis in the acute stage*

of the hand with ulnar deviation of the wrist and fingers, as shown in Fig. 301, is quite characteristic.

The acute stages are accompanied by a greater or lesser degree of malaise. There may be a low, irregular fever and loss of weight. General enlargement of the lymphatic glands is not uncommon, and the spleen may be palpable. There is usually anæmia of secondary type. The erythrocyte sedimentation rate is frequently raised and this gives some indication of activity and progress.

The condition is subject to remission at any time but the prognosis should be guarded because it cannot be foretold if a remission is temporary or permanent. The disease, even if treatment is unsuccessful in shortening its duration, eventually subsides If it is arrested at an early stage, the joints may return almost to normal; at a later stage the degree of functional recovery depends upon the amount of structural damage and the care with which deformities have been prevented. In a very severe case the feet are rigid and the toes clawed, movement at the hips and knees is painful and

greatly restricted, the hands are stiff, the fingers distorted, and even the elbows and shoulders may be involved. Fortunately it is uncommon for all joints to be damaged to the same extent and not many patients are reduced to this pathetic condition. It is more usual to find that there is a good range of movements at some joints, restricted painful movement at others, and ankylosis at only a few.

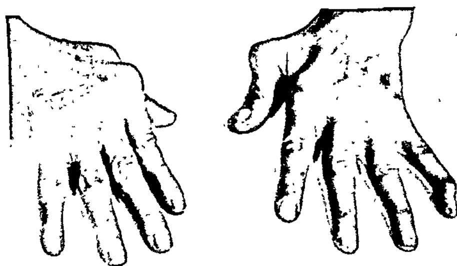


FIG 301 Oldstanding rheumatoid arthritis showing the deformity of the hands

**X-rays** (Figs. 302 to 305). The first demonstrable change is swelling caused by effusion into the joint and soft tissue thickening. This is followed by a general decrease in density of the juxta-articular region which later may become extreme and involve the whole end of the bone. There may be one or more "punched-out" areas of trabecular absorption. The joint space becomes narrowed as the articular cartilage is destroyed and ultimately there may be bony ankylosis. Marginal lipping often develops during phases of temporary or permanent arrest.

## Treatment

Rheumatoid arthritis is a systemic disease with local manifestations in the joints. As has already been indicated, a variety of factors play a part in causing and shaping the course of the disease. Environment, heredity, sex, age, emotional balance, physical and mental stress, body mechanics and chronic infection are all woven into the picture of the arthritic. One or other may predominate, but all may be concerned, and all must be considered when assessing an individual patient; there is no panacea and no specific remedy.

The aim of treatment is to shorten the course of the disease by providing the optimum general conditions, physical and mental, and to ameliorate the severity of the symptoms by local treatment designed to aid resolution, maintain function and prevent deformity. The following measures, some or all of which may be required for any one patient, are in general use.

GENERAL TREATMENT.

*Regimen.*
*Elimination of focal sepsis.*
*Vaccines.*
*Pyrotherapy.*
*Drugs.*

LOCAL TREATMENT.

*Rest.*
*Exercise.*
*Heat.*
*Massage.*
*Operation.*

**General Treatment.** REGIMEN. Rest for both body and mind is the first essential but economic conditions make this perhaps the hardest of all therapeutic measures. Mere absention from work is not synonymous with rest and ideally there should be the right environment and freedom from all financial, domestic and social worries ! The duration and completeness of physical rest depend on the acuteness of the attack. A period in bed is necessary whilst there is fever or tachycardia, but in a less acute case it may be sufficient to adjust the daily regime to allow set periods of rest. The judicious use of sedatives is important.

The diet should be well balanced—that is about the limit of scientific knowledge concerning diet in arthritis. The popular views on the harmful effect of red meats date back to the days when a man might consume a leg of lamb at a sitting and still call for more. The calorie intake should probably be restricted to the minimum necessary for the amount of work being done ; it should be low whilst the patient is in bed and then should be raised as activity increases. The composition of the diet should follow the previous dietetic habits and preferences of the patient with adjustments to ensure a sufficiency of all essential components.

It is very difficult to evaluate impartially many remedies that are so enthusiastically advocated in different quarters. Although each is sometimes followed by improvement, the results are not consistent and it is difficult to distribute credit between the alleged remedy and associated general measures. This applies particularly to treatment in spas and watering places which have proved their value during many centuries. Conditions in such places can approach the ideal—a regulated life with balanced rest and exercise, a wholesome diet and facilities for local treatment to the joints.

FOCAL SEPSIS, if it exists, should be eliminated as soon as possible, but there is no case for the indiscriminate removal of every organ that can harbour bacteria. The teeth and tonsils are readily accessible to examination and expert advice on their condition should be obtained. A careful history usually shows if there is reason to suspect an abnormality of the gastro-intestinal or genito-urinary tracts, and full bacteriological and



FIG. 302 Rheumatoid arthritis at an early stage showing rarefaction near the joints of the wrist and fingers



FIG 303 Rheumatoid arthritis at a later stage with more extensive decalcification There are "punched out" areas of trabecular absorption at the head of the first metacarpal and subluxation of the joint.

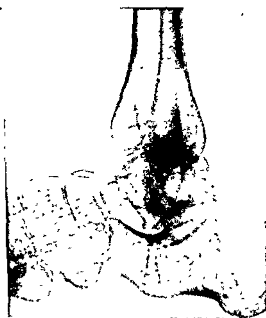


FIG 304 Advanced rheumatoid arthritis with generalised decalcification



FIG 305 Bony ankylosis of the hip following rheumatoid arthritis

GENERAL TREATMENT.

*Regimen.*
*Elimination of focal sepsis.*
*Vaccines.*
*Pyrotherapy.*
*Drugs.*

LOCAL TREATMENT.

*Rest.*
*Exercise.*
*Heat.*
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*Operation.*

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FOCAL SEPSIS, if it exists, should be eliminated as soon as possible, but there is no case for the indiscriminate removal of every organ that can harbour bacteria. The teeth and tonsils are readily accessible to examination and expert advice on their condition should be obtained. A careful history usually shows if there is reason to suspect an abnormality of the gastro-intestinal or genito-urinary tracts, and full bacteriological and

EXERCISE. Movement is commenced as the condition begins to improve. Splints are removed at first only once or twice a day for active and passive movements; later they are discarded during the day, but they should be worn at night for as long as there is a risk of deformity developing. Exercises are graduated to avoid fatigue, and they should include all muscle groups, not only those of the affected parts. Treatment under water in a warm bath is often of assistance because the support given to the limb facilitates active movements and reduces muscle spasm.

General postural defects are common in patients of asthenic build, and these form a large proportion of those affected with rheumatoid arthritis. Although such defects are not the cause of the disease, correction may improve the general health and materially assist recovery. Remedial exercises and postural re-education may therefore be of value, and particular attention should be paid to the muscles of respiration and those controlling the abdomen.

Manipulation under anæsthesia is only permissible when the disease is quiescent and then it may be of value in restoring movements and in correcting deformities, if the latter have been allowed to develop. It must be performed with extreme care to avoid damage to contracted ligaments, and it is better to repeat a small manipulation several times than to attempt too much at one session.

HEAT is used to increase the circulation by inducing local dilatation of the blood vessels. The temperature of deep structures can be raised by means of short-wave diathermy. Heat applied superficially by surface applicators such as hot-water bottles and electric pads, or by radiant heat, is immediately dissipated in the circulating blood and does not penetrate below the subcutaneous tissues. It is, however, possible that superficial heat causes reflex dilatation of the deeper vessels.

During the most acute stage heat should be avoided; it makes the pain worse, possibly because it increases existing congestion, and it increases effusion into the joint. In the sub-acute stage, superficial heat helps to reduce muscle spasm and may be comforting. In more chronic disease short-wave diathermy is often helpful. Full length heat baths have rather a different function because they induce general sweating and raise the body temperature; they are very fatiguing to a weak patient and should be prescribed with care and administered with caution.

MASSAGE, when skilfully administered, has the effect of "loosening up" joints and muscles and plays an important part in the treatment of arthritis. Both venous and lymphatic flow depend in part on movement of joints and muscles; fluid in the intercellular spaces becomes stagnant when movement is prevented by disease, and massage probably achieves its effect by assisting the blood and lymphatic circulation.

**Operation.** ARTHROPLASTY presents great problems because of the extent of fibrous tissue formation; not only do the joints stiffen again as time passes and fibrous tissue is re-formed, but the atrophied muscles often fail to recover sufficiently to give reasonable control. The chief difficulty is in connection with bilateral ankylosis of the hips, the knees

radiological investigations should be made if there is any indication to do so.

VACCINE THERAPY is the counterpart of the doctrine of focal infection. Autogenous vaccines made from bacteria obtained from a suspected focus are given in the hope of producing immunity to similar organisms that may be lodged elsewhere. Non-autogenous vaccines are intended to raise the general immunity. No harm, and sometimes benefit, follows the judicious use of vaccines, but damage may be caused by excessive dosage. The initial dose should be very small and a systemic reaction with fever and increased joint pain must be avoided.

PYROTHERAPY. Non-specific shock therapy, which consists in the induction of fever and leukocytosis by the injection of typhoid bacilli, milk or other foreign proteins, has had vogue which is now waning, but it may sometimes be helpful when the disease has become stationary after progressing favourably for a time. The same can be said of mechanical methods of raising the general body temperature.

DRUGS. No drug has any specific action although iodides, arsenic and salicylates are commonly administered. Various preparations of gold are used extensively and there is reliable evidence that in an appreciable number of patients the disease is arrested. Administration of gold is not without risk because there is sometimes an exceedingly severe reaction and therefore, although the reaction can usually be controlled with BAL, this treatment should only be undertaken at institutions where full laboratory facilities are available. Preparations of other metals, for example copper, have not been reported on favourably.

COLONIC IRRIGATION is mentioned only to condemn it. The lower bowel has been more abused during the treatment of arthritis than any other part of the body—and most accessible organs have been attacked on one excuse or another. To the untutored mind, lay or medical, there is something foul and unhealthy about that part of the body in which waste matter is accumulated before removal, and it is seldom appreciated that the bowel is specially designed for this purpose. Colonic irrigation is practised on an extensive scale although it can seldom be justifiable.

**Local Treatment.** This can be of great value if skilfully managed but harm may be caused by attempting to "force the pace." There are four procedures available—rest, exercise, heat and massage. The last three are additive in their fatigue effect and it is essential to regulate treatment so as to avoid both fatigue and pain.

REST. Unnecessary movement is contra-indicated during the initial acute phase and the joints should be placed at rest by splinting in the best functional position. This is conveniently managed by bandaging the limbs to light plaster-of-Paris splints. The splints should, however, be taken off daily and each joint moved through its painless range once only to prevent unnecessary stiffness. Particular care is necessary to prevent flexion contractures of knees, hips, fingers, wrists and feet; if they are doomed to ankylosis in spite of treatment, let it be in the best position.

Complete rest is essential and this can be managed most satisfactorily on a full-length plaster bed (Fig. 355, p. 458). It is often noticeable that when there has been no improvement with simple rest in bed, immobilization on a plaster bed is followed both by improvement in the general condition and by relief from joint pain. Specific treatment is disappointing and seldom has a demonstrable effect on the course, but the same investigations should be made as in adults.



FIG 307 Still's disease.

Contractures develop rapidly and must be carefully guarded against; a plaster bed is helpful for this also. Not infrequently almost every joint in the body is involved, and in a neglected case the deformities become grotesque and are most difficult to correct.

*Ankylosis*, fibrous or bony, is a common sequel. Surgical intervention may be considered after some years when the disease is completely quiescent and the likelihood of subsequent fibrosis is smaller. In the meantime, even when the joints are rigid, the muscles should be kept working by voluntary contraction and faradism; if the muscles retain some power of contraction, it may later be possible by multiple arthroplasties to make these unfortunate cripples able to look after themselves, and even become economically self-supporting.

and the elbows. Two stiff hips make sitting impossible and moving about a matter of great difficulty ; even a few degrees of movement are, therefore, greatly appreciated and an arthroplasty may seem worth while to the patient even when the result is a disappointment to the surgeon. Two stiff knees are a serious encumbrance, always getting in the way and making it hard to rise from a chair ; here also an arthroplasty giving even 45° of motion is a considerable improvement. Arthroplasty of the elbow is usually fairly successful and provides a useful range of movement ; the range selected should, however, be that which will be of most convenience to the patient, and the need most often expressed is not, as might be expected, but put the hand to the mouth, but to attend to the toilet when at stool (Fig. 306).



Fig 306 Arthroplasty of the elbow in rheumatoid arthritis showing the range of active movement

Arthrodesis is indicated for painful fibrous ankylosis, and sometimes for the correction of deformity. It is required chiefly at the foot, knee and wrist. The methods used are the same as when performing arthrodesis for other conditions and are described elsewhere.

### Still's Disease

This is an uncommon condition occurring during childhood. As far as is known it is fundamentally the same disease as rheumatoid arthritis, *although more acute (p. 386). The onset is accompanied* by fever up to 102° or 103°. There is general enlargement of the lymphatic glands which become hard and tender although they remain discrete. The spleen also is enlarged and palpable. Sweating is profuse. Anæmia may be severe, and there is often leukocytosis. The joints present a typical fusiform appearance, and muscle wasting may be rapid and extreme (Fig. 307).



Osteoarthritis of the Knee

[*To face page* 398

## OSTEOARTHRITIS

(*Synonyms*) Hypertrophic Arthritis, Degenerative Arthritis

### Ætiology

The view is taken, as has already been explained, that osteoarthritis is primarily a mechanical disorder caused by wearing out of the joint because of lack of congruity of the joint surfaces (p. 386). Mixed types also occur in which the original damage to the articular cartilage is due to rheumatoid arthritis, or in which there is a primary osteoarthritis with superimposed inflammatory changes of rheumatoid nature.

Osteoarthritis is essentially a condition of the second half of life but it is only too often seen at an earlier age as the result of trauma or disease of the joint. It is frequently monarticular although bilateral involvement of the knees and hips is common. It occurs principally in weight-bearing joints, and therefore in the joints of the lower limb; the shoulder joint seldom undergoes osteoarthritic changes because it is not in compression, but the elbow is sometimes involved, and the wrist more frequently as the result of trauma. The spinal joints proper, i.e. the lateral intervertebral joints, are not weight-bearing, and spinal osteoarthritis is much less common than is usually supposed. Lipping of the vertebral bodies has a different significance and must not be confused with osteoarthritis (pp. 53 and 76).

**Heberden's Nodes.** These are small swellings occurring in elderly people, usually at the terminal joints of the fingers, which are caused by proliferation of bone at the margins of the joints (Fig. 308). They are difficult to classify because although the pathological changes are those of osteoarthritis, the distribution and mode of onset are suggestive of a constitutional cause; they are probably examples of a mixed type of disease.

**Malum Coxæ Senilis.** Arthritis of the hips occurring in the elderly may sometimes be due to disease of mixed type, but often it appears to be the mechanical result of congenital subluxation or shallow acetabulum (p. 147), and on some occasions it develops for no discoverable reason.

### Pathology

**Articular Cartilage.** The earliest changes in osteoarthritis occur in the articular cartilage and are degenerative in character. The cartilage becomes discoloured, it softer [illegible] (fibrillation), and finally flakes off to expose th[illegible] [illegible]hole surface of the joint is not affected at once [illegible] to circumscribed patches, usually at the summit of the joint where the weight is habitually carried (Plate VI).

**Bone.** Eburnation. The bone underlying the patches of degenerate cartilage becomes dense and eburnated. Cancellous bone and the contained marrow are not exposed as in rheumatoid arthritis, and therefore bony ankylosis does not occur.

OSTEOPHYTES form as the result of chondro-osseous proliferation at the articular margins of the bone. It has been suggested by Nichols and Richardson that this process originates in the remnants of perichondrium ogether. At ne, but later The newly- nay become detached forming loose bodies in the joint and these cause further damage to the articular cartilage.





FIG 308 Heberden's nodes are due to osteophytic outgrowths around the terminal interphalangeal joints The photograph and X-ray are of different patients

CYST-LIKE SPACES containing yellow, gelatinous material often form in the juxta-articular bone. The ætiology is uncertain and it is not definitely known if they are caused by degenerative changes in the overlying cartilage, or if they themselves cause the cartilage to degenerate.

**The Synovial Membrane.** This may remain unaltered or else, usually rather late in the disease, it becomes thickened and convoluted. A curtain of pedunculated tags often forms round the articular margin of the bone.

**Capsule.** There may be no change, but sometimes the capsule is greatly thickened by fibrous tissue proliferation : the newly-formed tissue later contracts causing deformity and restriction of movement.

**Muscles.** Lack of use causes wasting but there is not the extreme atrophy of rheumatoid arthritis, nor do the muscles become fibrosed in a similar way.

**Limitation of Movement.** At first this is slight but it gradually increases. It may be caused by alteration in the shape of the articular surfaces, by impingement of painful osteophytes or hypertrophied synovial membrane, and at a later stage by contraction of periarticular tissues. Muscle spasm is not marked, but it does occur as a protective measure when the painful point in movement is reached.

**Deformity.** Alteration in the alignment of the articular surfaces and soft tissue contraction both cause deformity. It is often severe at the hip which is drawn into a position of flexion, adduction and external rotation ; indeed apparent shortening of the leg may be the first complaint in osteoarthritis of the hip.



Fig 310 Advanced osteoarthritis of the left hip There is a history of severe trauma some 20 years previously

**Swelling.** There is normally but little swelling although effusion into the joint frequently follows over use or minor injury. Loose bodies may cause transient locking and other acute symptoms.

**X-rays** (Figs. 309 and 310). The characteristic changes, any one of which may be the first to appear, are narrowing of the joint space, the [illegible] ...ces in the bone and osteo[illegible] [illegible] space, which [illegible] of [illegible] egins at the [illegible] one [illegible] more severely affected than the rest, for example at the knee where only one condyle may be involved (Fig. 151, p. 195).

Cyst-like spaces due to circumscribed areas of trabecular absorption sometimes appear before there are any other radiologically demonstrable changes. This is not infrequently the case in early osteoarthritis of the hip when such a space is often present at the upper angle of the acetabulum (Fig. 309). The subchondral bone is increased in density and, in advanced disease, the structure of the cancellous bone is altered for some distance from the joint, becoming fluffy and rather dense, and containing numerous cysts.

## Clinical Features

The onset of symptoms is usually very gradual but it may be accelerated by a minor injury, such as a sprain. At first there is *slight stiffness of the* joint which interferes with a particular movement and is noticeable only after exercise; pain begins rather later and is associated with movement. Progress is slow but steady and may be appreciable only over a period of months or years. The affected joints gradually become stiffer, and pain on movement greater, until finally a stage may be reached at which all useful movement is lost and there is extreme pain on attempting to use the limb.



Fig. 309 Early osteoarthritis of the hip with slight narrowing of the upper part of the joint, cysts in the upper angle of the acetabulum and new bone formation around the head of the femur

**Pain.** This is not proportionate to the extent of the bony changes but depends more on soft tissue involvement and therefore X-rays give no indication of the amount of pain there is likely to be. Newly-formed osteophytes and hypertrophied synovial tags at the articular margins are often both painful and tender to pressure.

Pain is not as a rule felt during movement through the free range, only when forced beyond it. It tends to be worse on first moving after a period of rest, for example on getting out of bed in the morning, or after sitting in a chair for some time. It wears off as the stiff joint is loosened by exercise, but it is worse after exercise carried to the point of fatigue.

Pain is sometimes increased by warmth, as when *in bed at night*; this is possibly indicative of an active process in bone such as "cyst" formation. Pain at night also occurs in advanced disease with great limitation of movement and is caused by unconscious movement during sleep.

when weight-bearing joints are concerned, to reduce the weight to a reasonable level and then keep it constant.

Occupation. Patients with sedentary occupations are often able to adjust their lives to match their functional capacity. Manual workers, however, may have great difficulty in continuing at work and the time comes when it entails an excessive amount of exercise and causes definite harm. Unfortunately the age of the patient usually makes a complete change of occupation difficult, even if his intellectual attainments would permit it; with younger patients the problem needs careful consideration in co-operation with social worker and resettlement officer. Retraining should begin early and not be left until the disease is far advanced.

**Local Treatment.** Physiotherapy assists in relieving pain and maintaining movement. The triad heat, massage, and exercise are each used at some stage during the treatment of most patients. Short-wave diathermy is well tolerated and is often the best method of applying heat, but patients vary in their response and it may be necessary to try several methods to find out which is the most suitable. Hydrotherapy and exercise under water may be of considerable value.

Manipulation under anæsthesia is occasionally of help in restoring movements but it must be carried out with care and without using excessive force or serious damage may be caused. It is more likely to be of value at an early stage and when the smaller joints, e.g. the tarsal joints, are affected. The ligaments of the larger joints like the hip cannot be stretched by manipulation, but skeletal traction continued for some weeks may be successful in decreasing deformity.

Joint Acidification, as introduced by Grant Waugh, has many advocates. It is effected by intra-articular injection of a preparation containing lactic acid. Injections are given at weekly intervals for six weeks and the course may be repeated several times with intervening periods of rest. A strict aseptic technique is essential; I have on two occasions seen suppurative arthritis following injections into the knee carried out in doctors' consulting-rooms.

Many patients have apparently benefited from this treatment but scientific assessment of the results is difficult. Osteoarthritis follows a very slow course and a follow-up over a prolonged period is necessary; no convincing series has yet been published.

Radiotherapy is sometimes successful in reducing the pain in osteoarthritis and is worth a trial, particularly when the spine is affected and surgical measures are impracticable. It is more likely to be of value when active changes are taking place in the structure of the bones, i.e. when the pain is increased by warmth.

Apparatus. Assistance can sometimes be given by apparatus that restricts movement at a painful joint, or relieves it from bearing weight. A weight-relieving caliper may be helpful when the hip or knee is affected, but not many patients tolerate it indefinitely and most prefer arthrodesis when this alternative is offered. Movements of the spine may be restricted by a brace or corset (p. 58), and the elbows can be controlled by a suitable

Proliferation of bone at the articular margins first appears as an increase in the sharpness of the outline of the joint, or as an exaggeration in size of a normal protuberance such as the spine of the tibia. Osteophytes develop later and may grow to a considerable size and entirely surround the joint.

## Treatment

Osteoarthritis is a local disease, as compared with rheumatoid disease which is a systemic disease, and therefore treatment is directed chiefly to the affected joint. When there is reason to suspect a constitutional basis, e.g. rheumatoid arthritis with an osteoarthritic overlay, investigation follows the lines already described for rheumatoid arthritis. But when the cause is obviously mechanical, as with osteoarthritis of the wrist following injury to the carpus, little benefit can be expected from constitutional measures; it is, however, worth while to treat an obvious septic focus in the hope of preventing secondary inflammatory changes.

The methods of treatment requiring consideration are:—

General Treatment.
- *Regimen.*
- *Occupation.*

Local Treatment.
- *Physiotherapy.*
- *Manipulation.*
- *Joint acidification.*
- *Radiotherapy.*
- *Apparatus.*
- *Operation.*
  - *Arthroplasty.*
  - *Arthrodesis.*
  - *Joint denervation.*

**General Treatment.** Regimen. The management of a patient with osteoarthritis is largely a matter of adjusting the regime to suit the functional capacity. Exercise is of great importance because the joints can be kept free only by movement. If carefully planned and carried out, exercise may prevent deformity and maintain a useful range of painless movements, at any rate for a long time. It is essential to avoid pain and fatigue, both of which have a harmful effect, as symptoms are noticeably worse on the day after an excessive amount of exercise. The amount of ordinary exercise that can be taken is discovered by trial; the intelligent patient is soon able to establish a regime that suits him, indeed he is often better able to do so than the doctor, but for other patients detailed guidance is necessary. Deliberate exercises are of value, even when an active life is being led, because they assist in maintaining movement in joints that might otherwise be protected unconsciously; a table of exercises to be performed daily should be worked out in co-operation with the physiotherapist.

Osteoarthritis often occurs in the sthenic, florid type of heavy body build which tends to run to fat in later life, and it is desirable, particularly

when weight-bearing joints are concerned, to reduce the weight to a reasonable level and then keep it constant.

OCCUPATION. Patients with sedentary occupations are often able to adjust their lives to match their functional capacity. Manual workers, however, may have great difficulty in continuing at work and the time comes when it entails an excessive amount of exercise and causes definite harm. Unfortunately the age of the patient usually makes a complete change of occupation difficult, even if his intellectual attainments would permit it; with younger patients the problem needs careful consideration in co-operation with social worker and resettlement officer. Retraining should begin early and not be left until the disease is far advanced.

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splint (Fig. 242, p. 310). For the wrist, arthrodesis is usually preferable to a permanent splint.

OPERATION plays an important part in the treatment of osteoarthritis. The chief indications are the relief of pain, the correction of deformity and the restoration of movement. When modern facilities are available there is no need for any patient with monarticular disease to spend his life in continual pain because it can be relieved with some certainty by operation, often without interfering with his earning capacity. Even if several joints are involved, it is usually possible to make life tolerable by some combination of operations.



FIG 311 Charcot's disease of the shoulder Atrophic type with little new bone formation

Two procedures are available, arthroplasty and arthrodesis. Arthroplasty is clearly the more desirable: it is still rather an uncertain business although in favourable conditions it restores reasonable function. Arthrodesis can be relied upon to relieve pain and therefore is the more usual operation when the disease is unilateral. Bilateral ankylosis of the hips, knees or elbows is a disability to be avoided at all cost, and arthroplasty should be attempted, at any rate on the first side to be operated upon. The problems concerned are discussed in the chapters dealing with individual joints.

*Joint denervation.* Interruption of the entire sensory nerve supply to a joint would relieve the pain with certainty, but since most joints receive branches from several nerves, it is seldom practicable to divide them all and the results are uncertain. The procedure is used most frequently at the hip (p. 151), and a method for denervation of the elbow has been described (Bateman). Section of the pain tracts in the spinal cord has also been practised but the results are not encouraging.

## NEUROPATHIC ARTHRITIS

(*Synonym*) Charcot's Disease

Neuropathic arthritis is a disease occurring when there is impairment of the sensory nerve supply of a joint. The commonest cause is tabes dorsalis, but it is also seen in syringomyelia, and occasionally in paraplegia of spinal or cerebral origin and after peripheral nerve injuries. The joints usually affected in order of frequency are the knee, hip, spine, foot, ankle and shoulder. Polyarthritis is uncommon.

An insensitive joint does not react in the ordinary way to disease or injury. This is partly because, in the absence of pain, there is no restraint of movement; it is probable, however, that other factors are concerned although they are not yet understood. If trauma plus the absence of sensation were the only explanation, neuropathic arthritis should be much more common than it is, and also it should affect more than one joint in a limb.



Fig. 312 Charcot's disease of the spine.

The pathological changes resemble those of osteoarthritis taking place at high speed, as if seen on an accelerated kinematograph; there is, however, more destruction of bone, and as a rule effusion is greater.

It is customary to divide neuropathic joints into two types: *atrophic* in which there is extensive destruction of articular cartilage and bone (Fig. 311), and *hypertrophic* in which new bone formation is on a massive scale, but pure types are unusual and it is more common for them to be mixed. In a typical example the joint is grossly disorganized, large areas of bone disappear entirely, and there is extensive formation of osteophytes (Fig. 156, p. 202). Occasionally osteophytes become detached in large numbers and the joint, when grasped, feels like a "bag of bones." In both types there is usually a large and persistent effusion into the joint which so stretches the capsule and ligaments that partial or complete dislocation readily takes place. A dry form without effusion also occurs but is less common.

The typical mode of onset is rapid swelling of the joint following a slight injury, such as a sprain. Deterioration is rapid and within a few months the joint may be more or less completely destroyed; the limb [illegible]

weak, the joint is unstable, perhaps flail, and frequently dislocated. Occasionally the course is more chronic; the effusion subsides and recurs at intervals, and the condition differs from osteoarthritis only in its comparative painlessness and in the extent of new bone formation. Clinical diagnosis can be made with some certainty when there is a painless arthritis with gross effusion in the presence of disease of the central or peripheral nervous systems.

## Treatment

Protection for the joint should be provided as soon as the diagnosis is made, and without waiting for the limb to become entirely useless, in the hope that deformity will be prevented and bone destruction limited. A weight-relieving caliper may be supplied for the foot, knee or hip; the elbow can be protected by a leather corset. No satisfactory apparatus for the shoulder has been devised, but protection is less important than for a weight-bearing joint. Fluid should be aspirated, if necessary repeatedly, and a pressure bandage applied to prevent the ligaments being stretched. Operation is contra-indicated because of the difficulty in obtaining fusion, and because it is said to increase the amount of bone destruction.

CHAPTER XIII

# TUMOURS OF BONE

## BENIGN TUMOURS OF BONE

### CHONDROMA AND OSTEOMA

A CHONDROMA is a tumour, initially composed of cartilage, which may either project outwards from the bone to form an exostosis (*ecchondroma*), or grow inwards into the substance of the bone (*enchondroma*). A chondroma of either type can occur as an isolated phenomenon, or several of one type or of both types may be found in the same individual. Sometimes there is a familial history. Ecchondromata, even when single, are regarded by some authorities as a localized form of diaphysial aclasis, but although this may sometimes be so, there is not as a rule any other disturbance in the growth of the bones and it is probable that the two conditions are distinct (p. 444).

#### Ecchondroma

Ecchondromata are the commonest benign tumours of bone. When they ossify, as is usually the case, they are also known as *exostoses, ossifying chondromata* and *osteochondromata*. They commence to form early in life although diagnosis may be delayed until they are of sufficient size to attract attention. The usual site of origin is near to an epiphysial disc but it is uncertain if the cause is some minor disorder in the normal sequence of growth, or if the tumour is merely an exaggeration of a normal protuberance intended for the attachment of a muscle. Ossification usually occurs at the same speed and in the same manner as in the parent bone, and growth ceases at the same time as the general growth of the individual concerned.

The typical exostosis (Fig. 314) is situated near the end of a long bone, often around the knee; it is attached by a broad base and points away from the growing end of the bone. It is composed of ordinary cancellous and cortical bone which is structurally continuous with the parent bone, and it is capped with a layer of calcifying cartilage at which growth takes place.

Symptoms are entirely mechanical; if the tumour is large it forms a tender projection under the skin, and sometimes it interferes with neighbouring structures, e.g. nerves, muscles and joints. There is seldom greater discomfort than a mild ache, unless there happens to be pressure

on a nerve. Some pathologists think that malignant changes occasionally take place in the cartilaginous cap which then assumes the characteristics of an osteogenic sarcoma, but this is not certain.

An exostosis should be excised if its size or the symptoms warrant interference.

## Enchondroma

*Enchondromata*, which may be single or multiple, develop within bone, and as they grow the bone is destroyed from within outwards, the cortex being reduced to a thin shell (Fig. 313). Occasionally the cortex is perforated and the tumour continues to grow outside the bone sometimes reaching a considerable size. Not infrequently it degenerates and liquifies leaving a cyst containing mucoid material, sometimes it ossifies completely or in part (Fig. 315), and it is thought that very occasionally sarcomatous changes occur. It is probable that enchondromata are ætiologically distinct from a similar condition occurring in dyschondroplasia (p. 451).



Fig 313 Enchondroma of the first metacarpal to which attention was drawn by a "spontaneous" fracture

The first sign of an enchondroma is usually swelling, but sometimes the bone fractures before anything abnormal is noticed. Pain is seldom prominent. *Treatment is by excision* of the cartilaginous mass together with its perichondrum, and if necessary, replacement by a bone graft.

## Osteoma

This uncommon tumour, which is also known as an ivory exostosis, results from overgrowth of bone, as distinct from cartilage. It may be difficult to differentiate an osteoma from an ossifying enchondroma on either clinical, histological or radiological grounds. It is sessile, not pedunculated, and is formed by deposition of lamellar bone.

Osteomata are usually found in connection with the bones of the skull, particularly the vault. They are of extreme hardness and occasionally grow to so great a size as to endanger life. The tumour may be found adhering like a limpet to the outer surface of the vault, or else it may originate in the frontal or sphenoidal sinuses, in the auditory meatus, in the antrum, or in the lower jaw, usually near the angle. When commencing in the frontal sinus it sometimes encroaches on the orbit.

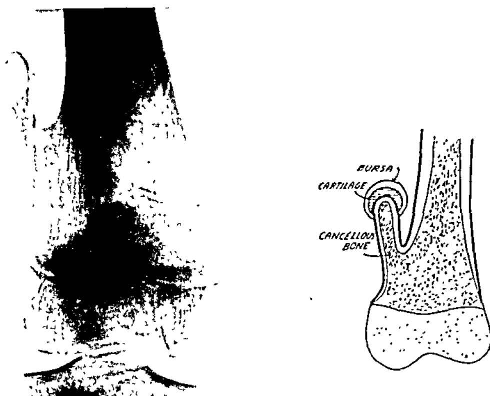



FIG. 314 Exostosis of the lower end of the femur.



FIG 315 Ossifying enchondroma in a young man complaining only of a lump at the inner side of the knee.



Fig 316. Solitary cyst of the humerus in a girl six years of age. It had not recurred fifteen years after resection



Fig 317 Localised fibrocystic disease that has recurred after curettage (by courtesy of Mr St J D Buxton)

## SOLITARY BONE CYSTS

The relationship of bone cysts to osteitis fibrosa and giant cell tumours is one of the most disputed points in the pathology of bone tumours. Whilst it is probable there is some kinship between them, the precise nature is not at present known and solitary bone cysts are described here as a separate entity.

Solitary bone cysts occur chiefly during the second, third and fourth decades of life, and almost always in the shafts of the femur, the tibia or the humerus, although examples have been described in other long bones. The cyst starts near an epiphysis but during growth it is carried along the bone and it may be some distance down the shaft when first diagnosed. Cysts in the metacarpals and phalanges are usually of a different nature and are produced by degeneration of enchondromata.

Symptoms are usually trivial and often escape notice, although there may be some swelling and deep-seated aching, and usually a "spontaneous" fracture is the first indication of trouble. Radiologically the cyst has a smooth outline and trabeculated appearance; it encroaches on the cortex which is therefore thin and may be slightly expanded (Fig. 316).

Other tumours which give rise to a similar or somewhat similar appearance are osteoclastoma, degenerated enchondroma, angioma, lympho-angioma, and localized osteitis fibrosa. The differential diagnosis from the first two of these may be very difficult even after biopsy.

**Treatment.** The trauma of a fracture, or of biopsy, often stimulates a simple cyst to heal and the structure of the bone then returns to normal. The procedure when there is a fracture through an area of bone having the radiological appearance of a cyst is, therefore, to splint the limb and await developments. When a cyst is found radiologically before there is a fracture, it is usually desirable to perform a biopsy; if there is doubt as to its character after histological examination, treatment is postponed until the true nature is revealed by serial X-rays taken at intervals of six weeks.

## LOCALIZED OSTEITIS FIBROSA

This is a rare form of bony dysplasia in which there are extensive fibrocystic changes. It may not be a separate disease entity and it is probable that the ætiology varies in different cases; some may represent atypical forms of osteoclastomata and others are possibly allied to solitary bone cysts. The condition has no relationship to osteitis fibrosa due to hyperparathyroidism.

As a rule only a single long bone is affected and this is usually the tibia although examples in most bones have been recorded. Both cancellous and cortical bone are replaced by a mass consisting of fibrous tissue and partly calcified bone in which there are cystic spaces, and the whole bone may be expanded (Fig. 317).

Complete removal of the diseased area is essential if recurrence is to be avoided. Conservative "curettage" and "scraping" is usually unsuccessful and complete resection should be carried out.



FIG 318 Osteoclastoma commencing in the metaphysis of the tibia of a boy aged 14 It was treated by excision and graft and had not recurred six years later.



FIG 319 Oldstanding osteoclastoma at the lower end of the tibia Malignant changes eventually took place and the limb was amputated

## OSTEOCLASTOMA

(*Synonyms*) Giant-celled Tumour, Myeloid Sarcoma

Osteoclastomata are benign tumours which occur at the ends of long bones in young people. *Growth commences in the metaphysis during* childhood and later spreads to the epiphysis. It is sometimes taught that these tumours originate in the epiphyses, but this view is almost certainly incorrect and is based on the observation of cases diagnosed late. The most common age for diagnosis is during the third decade because there are

... al tumour has a patchy yellow and red appearance from old hæmorrhage, and it is soft and friable to touch; in the earlier stages it is usually trabeculated. Microscopically it consists of large multinucleate giant cells embedded in masses of small spindle cells. Occasionally, as a rule at the lower end of the radius, the tumour is relatively avascular—the so-called "white myeloma." Malignant changes sometimes take place in large tumours that have been present for a very long time, and on rare occasions they *give rise to metastases, usually in the lungs.*

The bones principally affected are the upper end of the tibia, the lower end of the femur and the lower end of the radius. The growing ends of all the other long bones are occasionally involved, and also the pelvis, the vertebræ, the carpal and tarsal bones, and the mandible.

... y years, are pain, ... Not infrequently ... hæmorrhage into the tumour. At a later stage, when the bone supporting the joint surface has been destroyed, *the joint collapses* and there is deformity and loss of function.

The radiological appearance varies with the stage of development (Figs. 318 and 319). At first the lesion, which is placed asymmetrically in the bone, is confined to the metaphysis, but later the epiphysis is encroached upon. Both cancellous and cortical bone are destroyed leaving a smooth, lobulated outline. The cortex may be reduced to a mere shell and is often expanded, but there is no periosteal reaction.

**Treatment.** The choice of treatment lies between local removal of the tumour, resection of the affected length of bone, and radiotherapy.

Local Removal, when practicable, is regarded by many surgeons as the procedure of choice. It is, however, essential to remove the entire tumour and all its covering ... cavity ... with a ...

Resection of the affected length of bone is necessary only occasionally when the tumour is very large and the joint grossly disorganized.

Radiotherapy. Modern technique is yielding an increasing percentage of successes and in future it will probably be employed in most cases either alone or in combination with surgery.

## MALIGNANT TUMOURS IN BONE

The classification of malignant tumours in bone has not yet reached the stage of accuracy achieved with malignant disease of other structures. Classifications relating them to the supposed tissues of origin and to benign tumours of bone are attractively simple, but fallacious. There is nothing to be gained by following the elaborate nomenclature that is sometimes introduced and the simplest possible terminology is used here :—

PRIMARY TUMOURS.
- *Osteogenic sarcoma.*
- *Infiltrating chondroma.*
- *Ewing's tumour.*
- *Fibrosarcoma—extraperiosteal.*
  *—medullary*

HÆMOPOIETIC AND SIMILAR TUMOURS.
- *Myelomatosis.*
- *Leukaemia.*
- *Hodgkin's disease.*

METASTATIC CARCINOMA.

### Diagnosis

The diagnosis of a malignant tumour is always a responsible task, not only because failure to recognize its nature may deprive the patient of his only chance of life, but also because the opposite mistake may result in an unnecessarily mutilating operation. Malignant tumours of bone are particularly difficult to identify; no single investigation can be relied upon and it is essential to consider together all the clinical, radiological and laboratory evidence that can be marshalled.

**Clinical Findings.** Pain, tenderness and swelling are the outstanding clinical features; they may have no positive diagnostic significance, but the unexplained presence of any one of them is an indication for immediate investigation. The length of history should be compatible with the type of tumour under consideration.

**Blood Count.** The white cell count seldom exceeds 15,000 with tumours in bone. Persistent eosinophilia may accompany parasitic cysts.

**Blood Chemistry.** This may give an indication of decalcification due to causes other than tumours. An excess of "acid" phosphatase is often present in the serum when there are prostatic metastases, and Bence-Jones protein is found in the urine of many patients with myelomatosis.

**Wassermann Reaction.** A positive reaction, although suggestive, does not prove that the bony changes are due to syphilis because a tumour can develop equally well in a syphilitic subject.

**X-rays.** The corresponding site in the opposite limb should be X-rayed for comparison when looking for early changes, and if any doubt remains, the examination is repeated after a few weeks. Tangential views in several planes are helpful in detecting early erosion of the cortex. The whole skeleton must be examined for the presence of other tumours, and the

chest should invariably be X-rayed to exclude the presence of secondary deposits and tuberculosis.

**Biopsy.** It has often been suggested that surgical removal of a portion of a tumour may disseminate the growth, but it is now agreed by almost all authorities that there is no evidence that this is so. Biopsy is a most important diagnostic procedure and should be performed in nearly every instance. It is also of assistance in assessing the probable degree of radio-sensitivity of the tumour, and therefore the best method of treatment.

When performing a biopsy, a wide exposure is necessary to enable careful selection of the portion for removal; this should be large in size, of recent development, and include some healthy bone. A tourniquet should be used, but an Esmarch's bandage must not be applied over the site of the tumour. "Punch" biopsy provides a smaller amount of material and is apt to fail just when help is most needed; moreover it has been suggested that it increases the risk of dissemination because the small hole thus made in the cortex is rapidly sealed by clot and the tension in the traumatized area arises.

## OSTEOGENIC SARCOMA

Osteogenic sarcomata form the largest and most varied group of malignant tumours of bone. They develop for the most part in connection with persisting embryonic connective tissue, and since this retains the ability to differentiate into the component parts of bone to which it normally gives rise, the histological appearances are very diverse. The type of cell, the stroma in which the cells are embedded, and the amount of cartilage and of bone in the tumour vary greatly and the histology cannot always be correlated satisfactorily with either the radiological appearances or the clinical course (Scarff). The greater one's experience with this class of tumour, the more uncertain does one become in the interpretation of the pathological and radiological findings, and the more cautious is the prognosis given.

The types of cells commonly found in osteogenic sarcoma are spindle-shaped fibroblasts, small round cells and large polygonal cells; they are embedded in a stroma that may be abundant or scanty, and may consist of myxomatous, cartilaginous, osteoid or bony tissue. No tumour is composed entirely of one type of cell or stroma, and although one type may predominate, it is often possible to find typical areas of every type in a single tumour. Little is to be gained, therefore, by naming the tumour after the predominating tissue, e.g. myxosarcoma, chondrosarcoma, etc., nor is there any advantage in calling it periosteal or endosteal because the site of origin is frequently indeterminate. A distinction can usefully be made, however, between *osteoplastic* tumours which form bone more quickly than they destroy it, and *osteolytic* tumours which destroy bone more rapidly than it is formed.

The majority of tumours occur at the ends of long bones, usually at the diaphysial side of the epiphysial disc or in the subperiosteal region near one of the bony protuberances into which the larger muscles are inserted.

As the tumour grows it erodes the cortex of the bone from either the outer or inner surface according to the site of origin. It may spread along the medulla, and also under the periosteum lifting it up to form a mass beneath it, and it may penetrate the periosteum and infiltrate the surrounding soft tissues. The exact behaviour of an individual tumour depends on the balance between its natural tendency to grow and destroy, and the power of resistance of the body.

## Clinical Features

Some 60 per cent of all primary osteogenic sarcomata occur at the upper end of the tibia or lower end of the femur, and next in frequency is the upper end of the humerus; the other long bones are less often involved, and the flat bones only very occasionally. The incidence is greatest during the second decade of life, and considerably less during the third decade; few cases occur after forty years of age, except in association with Paget's disease, but instances have been reported at all ages. A history of trauma, either a single major injury or repeated minor injuries, is often obtained, and although the matter cannot yet be regarded as settled, trauma is probably an ætiological factor.

The characteristic symptoms are pain and swelling.

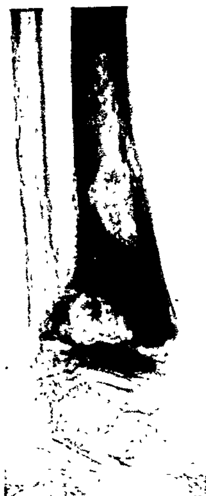
**Pain.** Some tumours are painless and then they are likely to escape early recognition, but pain is often the first indication that anything is amiss, and it is usually pain that brings the patient to consult his doctor. A patient under twenty years of age with pain in the region of the knee of sufficient severity to make him seek medical advice, and with tenderness on pressure over the bone, must have his complaint investigated fully and without delay.

**Swelling.** This follows pain after an interval of weeks or months. The size of the swelling varies very much with the particular tumour and often it seems as if it were larger than the X-rays suggest it should be. Sometimes swelling can be detected only on careful palpation, but sometimes it is considerable, the skin is stretched tightly over it, and the superficial veins are dilated. The tumour is usually firm and has an elastic, rubbery feeling, but when very large it may be soft and boggy.

Stiffness of the neighbouring joint, and also a limp, may develop later, but these are not constant findings. With osteolytic growths spontaneous fractures are common and may be the first symptom. The lymph glands draining the region of the tumour are sometimes enlarged. There may be a moderate leukocytosis which rarely exceeds 10-15,000, and sometimes there is a slight fever.

**X-rays** (Figs. 320 and 321). Some malignant tumours of bone have a typical radiological appearance and it is on these that the classical descriptions are based, but so many growths are atypical that no man can be dogmatic on this subject. Sometimes it is difficult enough to say if a tumour is malignant or benign, or, indeed, if the bony changes are due to new growth and are not the result of inflammation; to identify with certainty the type of growth that is present is often impossible.





*Above* Fig 320 Osteolytic sarcoma.

*Right* Fig 321 Osteoplastic sarcoma

The characteristic features are (a) destruction of bone accompanied by irregular new bone formation, and (b) a lack of definition, or outline, to the area of the growth. Osteolytic tumours usually commence centrally and spread asymmetrically; the cortex is destroyed, the periosteum is raised and new bone is often formed beneath it. In osteoplastic tumours dense new bone is formed which destroys the normal trabeculæ and obliterates the distinction between medulla and cortex; spicules of new bone radiate out from the shaft, raising the periosteum and giving rise to the classical "sun-ray" appearance. Growths commencing subperiosteally erode the cortex from without and may give it a mottled or stippled appearance due to alternating patches of bone destruction and bone formation. A large soft-tissue shadow, even when it has a definite outline, is suggestive of malignant disease provided it is accompanied by erosion of bone.

## Treatment

The prognosis is extremely bad, the duration of life seldom being more than a year or two in individuals under twenty, and only a few months in young children. A small number of patients with undoubted osteogenic sarcoma have, however, been cured by amputation, by resection of the affected bone, by irradiation, and by a combination of these procedures.

The choice of treatment depends to some extent on the site and the nature of the growth.

**Amputation.** This is more frequently practised in the lower limb, partly because there are few, if any, recorded cures following amputation of the upper limb, and partly because lower limb amputation causes less interference with function. The site of amputation should be the next site of election above the upper limit of the tumour. There is no need to amputate higher because metastases occur in the lungs and rarely in the proximal part of the limb.



FIG 322 Infiltrating enchondroma arising from the pubis close to the ilio-pubic junction It was excised

**Resection.** Local resection of the affected bone is sometimes practised before the tumour has spread outside the bone provided the limb retains reasonable function after operation, as may be the case with the fibula or the upper end of the humerus.

**Irradiation.** Many types of tumour are sensitive to X-rays or radium but the number of patients cured does not appear to be greater than by other methods. The general rule is that the greater the cellular differentiation, the poorer the response, but in practice there are many exceptions. When cure by any method is out of the question, it may be possible to control the local growth of a tumour by irradiation, and to prevent the dreadful pain so often associated with involvement of the brachial plexus and other nerves.

## INFILTRATING CHONDROMA

This not uncommon tumour of bone requires separate consideration because the clinical course is very different from that of osteogenic sarcoma, although in the terminal stages it may develop the same characteristic features. The tumour commences in an apparently benign form and may persist as such for very many years, even half a century, during which time it often grows to a great size. In many instances, however, it ultimately takes on the characteristics of a highly malignant osteogenic sarcoma and is rapidly fatal. Occasionally a chondroma of the pelvis gives rise to metastases in the lungs which have the same nature as the primary tumour even though there is no other evidence of malignancy.

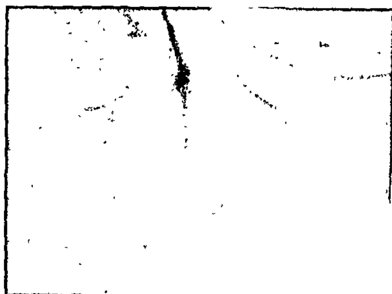
The tumour is arranged in a lobular manner and usually consists of well-formed cartilage with areas of cystic and hæmorrhagic degeneration ; irregular calcification causing a mottled radiological appearance is common. It grows outwards pushing the soft tissues away from it without invading them ; it also spreads along the medullary cavity of the bone eroding the cortex from within, a feature which may be regarded as evidence of local malignancy although metastases seldom occur at this stage. Lobules of the tumour implanted in the wound during operation frequently continue to grow, but the tumour can be regarded as truly malignant only after it has taken on the characteristics of an osteogenic sarcoma (Fig. 324).

### Clinical Features

The usual age for diagnosis is during the third, fourth and fifth decades ; this is later than other tumours because during the benign stage it may remain undetected for many years. The common locations are the diaphysial regions of both upper and lower ends of the femur, the upper end of the humerus and the pelvis. The site of origin in the long bones is usually one of bony protruberances to which the long muscles are attached, but in the pelvis the usual position is near the epiphysis of the crest of the ilium, or near one of the points where the component bones of the pelvis are joined together.

The only clinical sign may be swelling, and the patient is often unaware of the existence of the tumour until it is large enough to be obvious. The size may remain stationary for years, or it may slowly increase. Sometimes there is a history of vague pain. The onset of malignancy is difficult to determine but it is suggestive when a tumour that has been present for some time rapidly increases in size and begins to hurt. Biopsy is an essential diagnostic step but it will only establish malignancy if the right portion of the tumour is removed.

**X-rays.** The appearances are very variable. Sometimes tumours developing at epiphyses or in the pelvis closely resemble osteoclastomata (Fig. 323), but sometimes they are of massive size and are stippled with areas of calcification (Fig. 322). The outline is well defined and often lobulated, but definition is lost after the tumour has spread outside the bone (Fig. 324).



*Above* Fig 323 Infiltrating enchondroma arising from the pubis close to the ischio-pubic junction.



*Right* Fig 324 Infiltrating enchondroma in which malignant changes have occurred

## Treatment

Because of the risk that it will later become frankly malignant, an infiltrating chondromata should be excised, or the limb amputated. It is essential to remove the entire tumour or malignant degeneration may be precipitated in the remaining portion, and a difficult decision has to be made when ablation of the neoplasm involves a crippling procedure. Both the tumours illustrated in Figs. 322 and 323 were excised complete with the bone from which they originated. Chondromata are highly differentiated tumours and do not respond favourably to irradiation which is therefore of doubtful value during the benign stage.

## EWING'S TUMOUR

This is a very uncommon tumour and some authorities deny that it is a separate disease entity. It consists of masses of small round cells which are commonly believed to be of endothelial origin, but precise descriptions of the ætiology vary.

The condition is primarily one of childhood and adolescence; 50 per cent of cases occur before the age of twenty, 80 per cent before thirty, and it is exceptional after forty (Kolodny). Males are affected twice as frequently as females. The usual site is the shaft of a long bone, but any bone may be affected. The prognosis is not very good and unless the tumour is rapidly controlled metastases occur in the lungs, in the lymphatic glands and in other bones. The frequency with which other bones are involved, particularly the skull, the spine and the shoulder girdle is a characteristic feature of the disease.



FIG 325 Ewing's tumour (by courtesy of Prof H. J Seddon)

**Clinical Features.** The early symptoms are pain and pyrexia occurring in intermittent attacks. There is a strong resemblance to an acute infection, so much so that osteomyelitis is nearly always the first diagnosis to be made. At a later stage there is a swelling which tends to vary in size from time to time, and usually marked tenderness. There is some leukocytosis but the white cell count is seldom over 15,000.

**X-rays** (Fig. 325). T[illegible] one; the cortex becomes thick[illegible] new periosteal bone is laid down. Successive depositions of periosteal bone may cause a typical "onion skin" appearance in which there are several concentric laminæ of new bone around the shaft. At a later stage the tumour extends along the bone and destruction of both cortex and medulla is more marked.

**Treatment.** Ewing's tumour is highly radiosensitive, indeed the rapid response to irradiation is strong confirmatory evidence of the diagnosis, but although the immediate response is good, many patients eventually die from metastases.

## FIBROSARCOMA

Sarcoma arising in the outer layers of the periosteum and adjoining soft tissues, or in the marrow cavity, is not truly a tumour of bone but it is included here because it invades bone and may closely resemble osteogenic sarcoma. It is of fibroblastic origin and the histological picture is essentially the same as fibrosarcoma arising elsewhere in the body. The *predominant cells may be primitive oat-shaped cells, spindle cells or* fibroblasts according to the degree of differentiation ; the more primitive the cell type, the greater the degree of malignancy.




Fig 326 Extraperiosteal fibrosarcoma



Fig 327 Medullary fibrosarcoma

There is a smaller group of closely related tumours composed of muscle elements (*rhabdomyosarcoma*), or nerve elements (*neurogenic sarcoma*), which also invades bone. Both are very similar to fibrosarcoma in behaviour, but they are generally of greater malignancy and permanent cure is almost unknown with any form of treatment.

Fibrosarcomata are divided into two clinical types, *extraperiosteal* and *medullary*, according to the site of origin.

### Extraperiosteal Fibrosarcoma

This tumour has a predilection for the lower end of the femur and upper end of the tibia but it may occur anywhere in the shafts of the long bones and sometimes in the ribs. The condition affects chiefly young adults, and although no age is immune, the maximum incidence is during the fourth decade. The prognosis depends on the histological nature of the growth; the greater the degree of differentiation, the more favourable the response to treatment. Metastases occur in the lungs and seldom in the regional lymph glands.

The symptoms are pain and swelling followed, if the tumour is near a joint, by dysfunction of the joint. The swelling is firm and rubbery in consistence and usually has a smooth outline.

**X-rays** (Fig. 326). The typical features are the size and density of the soft tissue shadow and a tendency to erode the bone from without. The bone may have only a saucer-shaped depression where it is in contact with the tumour, or it may be invaded and destroyed giving an appearance which resembles that in osteogenic sarcoma. Calcification of the substance of the tumour is exceptional.

Parosteal lipoma and benign periosteal fibroma give a picture similar to fibrosarcoma seen at an early stage when there is only a slight depression in the bone. These are both very rare tumours, there is even some doubt as to whether periosteal fibroma exists in a benign form, and pre-operative diagnosis is unlikely.

***Treatment.*** An experienced bone pathologist is able to determine the degree of malignancy with some accuracy and it is tempting to treat tumours of low malignancy conservatively by local excision. Geschickter and Copeland, however, could find no instance in which local operation was successful. There is generally a poor response to irradiation, but amputation gives a good percentage of lasting cures and is probably the best procedure when the position of the growth permits it.

### Medullary Fibrosarcoma

Fibrosarcoma originating in the medulla of the bone is even more uncommon than the extraperiosteal type, but it has the same histological features, the same skeletal distribution and a similar clinical course.

**X-rays.** The appearances are diverse and a positive diagnosis is usually made only after biopsy. The more slowly growing tumours erode the bone from within (Fig. 327), but those of rapid growth infiltrate the bone and resemble osteogenic sarcoma.

**Treatment.** The response to radiotherapy is poor, and even with growths of low malignancy, neither local removal of the tumour nor resection of the affected length of bone is likely to be successful. Amputation is usually the procedure of choice, and if local excision has first been attempted on a mistaken diagnosis, the limb should be removed as soon as a histological examination has been made.

## MYELOMATOSIS

(*Synonyms*) Kahler's Disease, Myeloid Sarcoma

This condition is not a true tumour of bone but a disseminated malignant disease which usually, although not invariably, involves bone. The common type consists of plasma cells (*plasmocytoma*), but tumours composed of myelocytes (*myelocytoma*) occur very occasionally, and tumours of erythroblasts (*erythroblastoma*) have been described. The source of the cells is not known, nor if the malignant process commences at a single site or has a multifocal origin. The following description refers only to the plasma cell type.

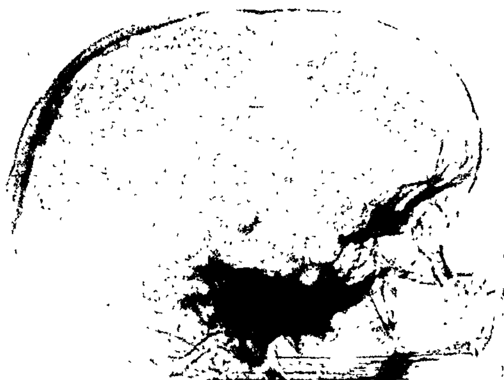


Fig 328 Myelomatosis with multiple deposits in the skull

The disease is one of adult life, usually late middle age, and males are affected more than females. In the typical form there are multiple deposits in the skeleton at the time of diagnosis. The bones chiefly affected are the ribs, vertebræ, sternum and skull, but the femora, pelvis, humerus, and indeed any other bone, may be involved. The tumours commence in the bone marrow and do not as a rule grow to a size exceeding an inch in diameter, but sometimes the affected bones are diffusely infiltrated and their internal architecture is completely destroyed.

The tumour is occasionally solitary at the onset but subsequently spreads to other bones, and very rarely it remains solitary without further dissemination. Spread to the soft tissues, particularly the liver and spleen,

is common in the terminal stages, and the bloodstream may be invaded by plasma cells (*plasma cell leukaemia*).

A peculiarity of the multifocal form of the disease is the excretion of Bence-Jones protein in the urine of rather more than half the cases (it is also present on rare occasions in a variety of other conditions). This protein precipitates on warming to 50°C., disappears on boiling, but re-appears on cooling again. The serum protein is often raised but it is not certain that the excess is of the same nature as the protein in the urine. In some patients the kidneys are damaged by blockage of the tubules, probably by Bence-Jones protein, and this causes nitrogen retention.

*Primary extra-osseous tumours* are uncommon, but they do occur. The usual sites are the upper air passages, the mouth and the larynx, and very rarely elsewhere. The course may be comparatively benign, but some tumours are locally malignant, and others become disseminated and give rise to secondary involvement of the skeleton.



FIG. 329 Diffuse myelomatosis

**Diagnosis.** Attention to the presence of the disease is usually attracted by pain, or by the occurrence of a "spontaneous" fracture. The typical X-ray picture shows multiple, roughly circular, areas of rarefaction with sharply defined margins (Fig. 328); occasionally there is diffuse infiltration and gross destruction of both cortex and medulla of the affected bones (Fig. 329). A solitary plasmocytoma often resembles an osteolytic carcinomatous deposit, but it may be cystic and trabeculated.

Diagnosis is simplified when there is Bence-Jones protein in the urine, but histological examination is often necessary. Sternal puncture is of value because the sternal marrow is frequently involved.

**Treatment.** The generalized affection, although sometimes fulminating, follows a rather slow course lasting a couple of years and is always fatal in the end. Individual tumours respond well to radiotherapy but the general course is not affected. Pain in the bones may be alleviated by irradiation, and fractures often unite after treatment; root pain due to vertebral collapse is, however, a distressing feature that is difficult to relieve. The prognosis with solitary tumours is better and it may be possible by irradiation both to destroy the local growth and prevent its dissemination.

## LEUKÆMIA

Bone destruction occasionally accompanies both lymphatic and myelogenous types of leukæmia. The characteristic radiological picture shows osteoporosis and small, punched-out areas of cortical erosion. In rare instances greenish tumours (*choloroma*) are formed in the skull, vertebræ, sternum or long bones.

## HODGKIN'S DISEASE

Invasion of bone by Hodgkin's tissue not infrequently occurs in the later stages of this disease (Fig. 330). The bone is infiltrated and destroyed, and there may be marked periosteal proliferation. The local affection of bone can often be controlled by X-radiation, and improvement has recently been reported following the use of radio-active isotopes and of nitrogen mustard.



FIG 330 Hodgkin's disease with involvement of the femur

## METASTATIC CARCINOMA

Every type of epithelial tumour may give rise to skeletal metastases, but some do so with relatively greater frequency than others either because tumours have a varying affinity for bone, or because the resistance of bone to invasion varies with the type of tumour. Geschickter and Copeland give the following figures :—

| | Number of cases | Number with osseous metastases | Per cent |
|---|---|---|---|
| Carcinoma of thyroid* .. .. .. | 15 | 6 | 40 |
| „ „ kidney .. .. .. .. | 63 | 22 | 35 |
| „ „ lung .. .. .. .. | 24 | 4 | 17 |
| „ „ prostate .. .. .. | 1040 | 134 | 13 |
| „ „ breast .. .. .. .. | 1914 | 100 | 5 |
| „ „ female genital organs .. | 147 | 7 | 5 |
| „ „ gastro-intestinal tract .. | 1034 | 11 | 1 |
| „ „ other sites .. .. .. | — | 50 | — |
| Total | — | 334 | — |

The commonest secondary deposits to be found in bone do not, however, come from the thyroid, kidney and lung because of the comparative infrequency of these tumours, but from the prostate and breast in which malignant growths occur so often. The site of origin of the 334 metastases in bone listed above is :—

| | | |
|---|---|---|
| Prostate . .. . .. | 134 = | 40 per cent |
| Breast . .. .. .. | 100 = | 30 per cent |
| Kidney .. .. .. .. | 22 = | 7 per cent |
| Gastro-intestinal tract .. .. | 11 = | 3 per cent |
| Female genital organs .. .. | 7 = | 2 per cent |
| Thyroid .. .. .. .. | 6 = | 2 per cent |
| Lung .. .. .. .. | 4 = | 1 per cent |
| Other sites .. .. .. .. | 50 = | 15 per cent |

The frequency with which different bones are involved also varies slightly with the origin of the tumour. For the breast it is spine, pelvis, femur, ribs, and cranial bones in that order; the prostate has a similar order but with a greater proportion in the pelvis and the lumbar and sacral vertebræ, and with renal metastases the incidence in the humerus is about equal to that in the femur.

### Clinical Features

The appearance of a secondary deposit may be the first intimation of malignant disease, especially of the kidney, but usually the presence of a primary tumour is already known to both patient and doctor. Many patients, whether the primary tumour has been treated or not, are so

* The percentage of cases of carcinoma of the thyroid in this series giving rise to skeletal metastases is rather higher than is generally accepted Ehrhardt found 24% in a series of 238 cases

fearful of recurrence that they report any trivial pain at once, but others cannot admit even to themselves the possibility of such a happening and conceal the advent of new symptoms until life has become intolerable.

The symptoms vary with the bone affected and the nature of the tumour. Osteolytic deposits tend to cause more trouble than osteoplastic because the destruction of bone makes it liable to collapse or to fracture. Osteoplastic deposits may only be discovered during routine radiological examination, and it often happens that for a long time they cause few, if any, symptoms.

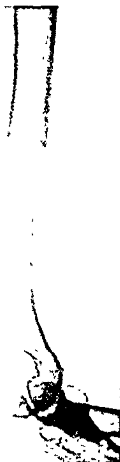


Fig 331 Osteolytic metastasis from a carcinoma of the breast.

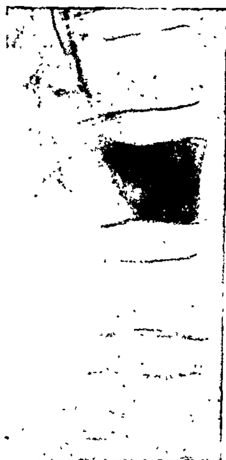


Fig 332 Osteoplastic metastasis from a carcinoma of the prostate

Deposits in the spine, the commonest site, may at first cause only slight and fleeting pain, or the earliest sign may be the development of deformity consequent on vertebral collapse. Later the pain becomes more serious, and should the nerve roots be encroached upon either by direct spread of the growth or by pressure of the collapsed spine, it may become one of the most intolerable and intractible pains that mankind is called upon to suffer. The first evidence of a deposit in a long bone is sometimes pain, and sometimes a "spontaneous" fracture. Headache is a characteristic symptom of cranial deposits.

*Carcinoma of the prostate* may give rise to secondary deposits before a prostatic tumour can be detected clinically; indeed malignant changes in the gland are often discovered only after it has been removed and examined histologically. Skeletal metastases are frequently osteoplastic and cause an increase in both the density and the size of the bone. When there is very extensive dissemination sufficient bone marrow may be destroyed to produce a severe secondary anæmia. The differential diagnosis from Paget's disease, which may be difficult on radiological grounds alone, is facilitated on those occasions when there is an excess of "acid" phosphatase in the blood serum because this seldom occurs in other conditions than prostatic metastases.

**X-rays.** In osteolytic tumours the outstanding feature is destruction of bone (Fig. 331). The initial deposit is often central and it gradually spreads eroding and destroying the cortex; there is seldom much periosteal reaction. There may be but a single bony lesion, or there may be deposits in several bones (the entire skeleton should always be examined), and sometimes there are multiple foci riddling the bones as if with myelomatosis. In osteoplastic tumours bone formation proceeds more rapidly than bone destruction and there are areas of increased density of amorphous structure. (Fig. 332). Osteolytic and osteoplastic areas may occur in different parts of the same bone at the same time.

## Treatment

The response to irradiation is, in general, similar to that of the primary tumour. As a rule any particular metastasis can be caused to regress and the bone re-ossifies, but sooner or later other metastases appear in bone and elsewhere, and they cannot be controlled indefinitely—life is prolonged, but not saved. Pain of a major character due to nerve involvement can often be alleviated by irradiation, but occasionally it is necessary to resort to division of the spino-thalamic tract and other operative procedures.

Metastases from the prostate behave similarly to the primary tumour when treated by castration or with stilbœstrol; they often regress and may be kept in control for a considerable time.

CHAPTER XIV

# DISEASES AND CONGENITAL DEFECTS OF BONE

## METABOLIC AND OTHER DISEASES AFFECTING BONE

### AVITAMINOSIS D

A SUFFICIENCY of vitamin D is essential to the normal metabolism of bone. Bone is not a static material but is subject to perpetual change and throughout life there is a constant process of bone destruction balanced by new bone formation. In the absence of vitamin D bone formation is interfered with because the newly formed osteoid tissue is unable to calcify properly. The result of this is twofold : developed bone gradually becomes softer because when it is broken down in the ordinary course of metabolism it is replaced by incompletely calcified osteoid tissue ; and in children osteoid tissue formed at the growth discs fails to calcify fully. In avitaminosis D occurring in children, therefore, both developed bone and the growth discs are affected, the condition then being known as rickets ; in adults only developed bone is involved and it is called osteomalacia.

#### Osteomalacia

This is a disease of adults characterized by softening and bending of the bones which may advance to an extreme degree. It is seldom seen in western countries although occasional examples occur as the result of inborn errors in calcium and phosphorus metabolism that are not fully understood ; it is, however, prevalent in northern India, in parts of China and in Japan.

There are two sources of supply of vitamin D ; it is produced in the skin by the direct action of the sun, and it is contained in certain foods, notably animal fats. In China the staple diet is grossly deficient in vitamin D ; the hours of sunshine, however, are long and since the children play out of doors almost naked, they have sufficient vitamin D, and therefore infantile rickets is uncommon. Older girls and married women, however, live mainly indoors, and because neither source of vitamin D is available, they are liable to develop adolescent rickets or osteomalacia, particularly during pregnancy and lactation when the demand for calcium is greatest. Men working in the fields continue to be protected by the sun and do not suffer from avitaminosis D.

## Rickets

Rickets is a disease occurring only before the epiphyses have closed and the principal changes are at the growth discs where the newly formed osteoid tissue fails to calcify. Softening of the shafts of the bones takes place as in osteomalacia, but this is a comparatively slow process and there may not be time, before treatment is begun, for it to progress to an extent that can be detected clinically.

Rickets occurs at three phases of life, in utero, in infancy, and in adolescence, and also as a complication of diseases such as cœliac disease in which the absorption or metabolism of fats and vitamins is at fault.

**Fœtal Rickets** occurs when the mother is grossly deficient in vitamin D, i.e. when she has osteomalacia, and therefore it is seen only in countries where osteomalacia is prevalent. The fœtal bones show the ordinary changes of infantile rickets.

**Infantile Rickets** is the form commonly seen in western countries and is further considered below. It occurs during the period of rapid growth after breast-feeding has ceased when the new diet is defective. Western children during much of the year are protected from the sun by clothes and therefore they are unable to make good for themselves a dietary deficiency in vitamin D.

**Adolescent (or Late) Rickets** also occurs during a period of rapid growth when there is a great demand for vitamin D and calcium. It is produced by the same conditions as osteomalacia and is seen in western countries only on rare occasions when some disorder of metabolism is present.

**Cœliac Rickets.** Cœliac disease is an affection of infancy characterized by diarrhœa with bulky, offensive, fatty fæces, severe wasting, and stunting of growth. Rickets occurs as a complication because the inability to absorb fat from the intestines starves the child of fat-soluble vitamins, and of calcium and phosphorus. During the severest stage of the disease, the bones stop growing entirely and therefore, because no osteoid tissue is formed, the characteristic changes of rickets in the epiphysial discs cannot develop. When growth recommences the typical changes of ordinary infantile rickets are likely to develop unless they are prevented by ensuring a sufficient supply of vitamin D by irradiation with ultra violet rays.

## INFANTILE RICKETS

Rickets in western countries is a disease of infancy occurring between the ages of six months and three years. It first became endemic in England during the earlier part of the seventeenth century and continued rampant until recent times. Now, thanks to an improved dietary and more enlightened views as to hygiene, the incidence has greatly decreased; florid rickets is quite a rarity and even minor degrees that are severe enough to affect the development of bone are becoming quite uncommon.

## Pathology

Deficiency of vitamin D has a twofold effect on the skeleton. The first is that the bones soften because the osteoid tissue which is formed during the ordinary process of remodelling is deficient in calcium. The second and most striking change is at the epiphysial discs (Plate VII). In the normal epiphysis the proliferating cartilage cells become arranged in orderly columns parallel to the axis of the bone, and these cells mature and increase in size as the diaphysis is approached. The columns of cells divide the cartilaginous matrix into trabeculæ, and calcium is deposited in the diaphysial ends of the trabeculæ forming a zone about 4 to 6 cells deep called the zone of provisional calcification. As the cartilage cells mature they are destroyed and replaced by vascular loops growing from the diaphysis; and the trabeculæ, which are now separated by the vascular loops, are covered by a deposit first of osteoid tissue and then of bone.

In rickets the epiphysial disc is very much thicker than normal; all zones are widened including the zone of provisional calcification, but this last may be quite indistinct or absent. There is complete absence of the normal regular arrangement and the disc consists of a disorderly mass of cartilage cells, trabeculæ, osteoid tissue and poorly calcified bone. The vessels enter the cartilage in all directions, and islets of cartilage may persist high in the diaphysis.

The breadth of the epiphysial disc is increased by the deposition of osteoid tissue under the perichondrium, thus causing enlargement of the end of the bone.

The changes are most marked in the larger long bones. The epiphyses are enlarged, growth is checked, and after a time the bones soften and bend in such a direction as to increase the normal curvature. Fractures, particularly greenstick fractures, occur readily and the callus is exuberant and soft.

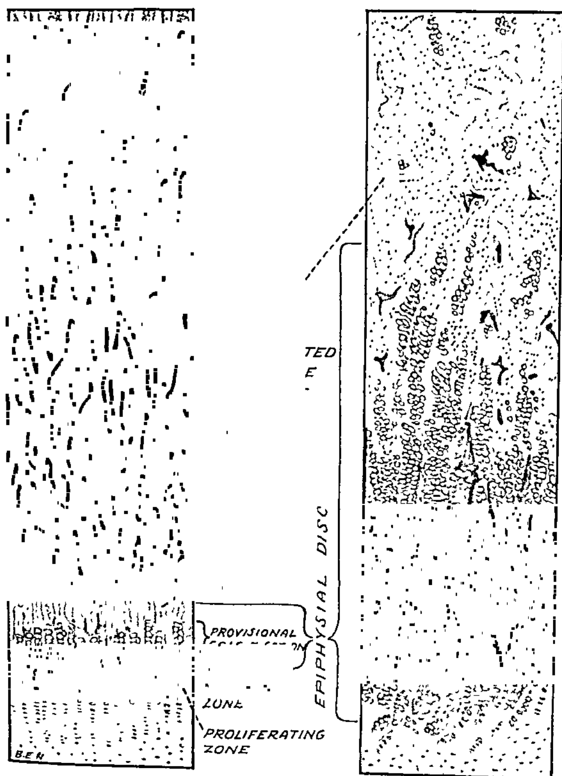
## Clinical Features

The full picture unfolds gradually as the condition progresses from the earliest sub-clinical stage to florid rickets.

The typical case occurs during the second half of the first year of life. The first symptoms to be noticed are not infrequently restlessness and irritability; the infant may appear healthy and is often fat, but the muscles are flabby. The fontanelles are wider than normal and areas of softening may be palpable in the cranial bones, specially in the posterior parts of the parietal bones. The X-rays at an early stage are normal.

The appearance when the disease is well-developed is characteristic. The child looks flabby and unhealthy and has a protuberant abdomen, but wasted limbs; the head is square, the thorax distorted and a "rickety rosary" is palpable. The epiphyses of the long bones are enlarged and the legs may be deformed.

**Deformities.** The gross deformities so common in the last century, and even in the first two decades of this century, are now seldom seen in Great Britain.




Normal

Rickets.

THE EPIPHYSIAL DISC

Magnification × 30 (approx.) Stained H. and E.

N.B.—Osteoid tissue is not shown by this method of preparation

[To face page 432

The ribs are usually affected severely in florid rickets. Enlargement of the costo-chondral junctions produces the typical "rickety rosary," and softening of the shafts of the ribs allows them to bend at points of stress, e.g. at the attachments of the diaphragm to form a Harrison's sulcus.

Deformities of the legs are due partly to irregularity in growth of the epiphyses and partly to softening. The femora bend outwards causing knock knee (p. 27), and the tibia curve inwards and often backwards causing bow legs (p. 30). Sometimes both deformities are combined and then the legs look fairly straight on casual examination.



FIG 333 Florid rickets

The pelvis is not infrequently compressed into a characteristic tri-radiate shape. The femoral necks bend causing coxa vara (p. 143). The skull becomes soft (craniotabes), and the fontanelles are abnormally wide. Deformities of the spinal column occur when the disease continues unchecked for a long time.

**X-rays** (Fig. 333). The first changes are often in the wrist (lower end of ulna) and knee. The extremity of the metaphysis first loses in density, then it becomes concave or "cupped" and its outline blurred. Later the metaphysis is broadened, sometimes becoming bulbous, the cupping increases and the concavity of the cup appears "frayed" or "feathery." After treatment, the structure of the bone gradually returns to normal.

## RENAL OSTEODYSTROPHY

(*Synonym*) Renal Rickets

This is a syndrome in which chronic uræmia, especially uræmia due to congenital abnormalities of the kidneys or congenital dilatation of the ureters, is accompanied by extensive changes in the skeleton. The exact chain of events leading to these changes is not certain but at least two factors may be concerned :—

(1) Chronic renal failure. This is sometimes followed by parathyroid hyperplasia which in turn causes changes in the bones of a fibrocystic type.

(2) Impairment in the absorption of calcium leading to an actual or relative loss of calcium. The impairment in absorption may be due to acidosis, or to an excessive intestinal excretion of phosphates, the excess combining with freshly ingested calcium to form an insoluble calcium phosphate.



FIG 334 Renal osteodystrophy

The radiological changes in the bones consist in (*a*) general decalcification and (*b*) changes in the epiphysial discs closely resembling those in florid rickets (Fig. 334). The histological appearances, however, are closer to those of osteitis fibrosa. Closure of the epiphyses is delayed, but growth is slow and many patients are so stunted as to warrant description as "renal dwarfs." Administration of vitamin D is without effect on the condition.

Progressive knock knee is a common feature and in mild cases it may be the first symptom to appear. The administration of an anæsthetic requires special care when there is renal failure and this must always be excluded before operating on a child with knock knee.

## AVITAMINOSIS C

(*Synonym*) Scurvy

Scurvy, a disease due to deficiency of the water soluble vitamin C, is now a rarity in most countries although an occasional case still occurs as the result of excessive zeal in the sterilization of infants food—vitamin C is rapidly destroyed at a temperature of 100°C.

The disease, which is characterized by capillary hæmorrhage occurring in any part of the body, appears to be associated with a disorder in normal fibroblastic differentiation. The conspicuous feature in infants is subperiosteal hæmorrhage at the ends of the long bones, usually of the lower limbs. The legs become slightly swollen and exceedingly painful to touch ; they are held quite immobile, as if paralysed, and any attempt to move them is vociferously resented. There may also be bleeding from the kidneys and intestines, and from the gums if the teeth have erupted.

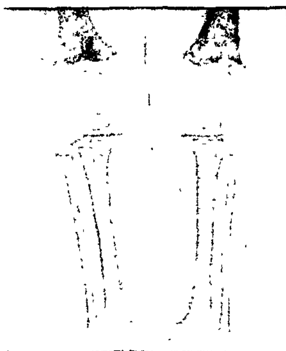


Fig 335 Scurvy

The X-rays (Fig. 335) in infants show general osteoporosis with thinning of the cortical bone and possibly some subperiosteal new bone. At the extremity of the diaphysis there is a line of dense bone with a radio-translucent line ("the white line") next to it. The ossifying centres of the epiphyses are sharply outlined.

Scurvy also occurs in adults, usually sailors and arctic explorers, when they are deprived of fresh foods for long periods. Hæmorrhage occurs first from the gums and later under the skin and mucous membrane. In severe cases there may be localized subperiosteal hæmorrhages ; when a subcutaneous bone is affected the overlying skin breaks down to form a foul ulcer, and occasionally the bone becomes necrotic.

## HYPER-PARATHYROIDISM

Enlargement of the parathyroids occurs in at least two different sets of circumstances :—

(1) *Primary.* A primary adenoma affecting a single parathyroid gland and causing generalized fibrocystic disease.

(2) *Secondary.* Parathyroid hyperplasia affecting all the parathyroid tissues ; it occurs secondarily to chronic renal failure, osteomalacia and occasionally other generalized affections of the bone. It may cause some decalcification of the skeleton, but not to the extreme extent occurring in generalized fibrocystic disease.

### Generalized Fibrocystic Disease

(*Synonym*) von Recklinghausen's Disease

This condition is the result of the excessive secretion of parathyroid hormone due to the presence of a parathyroid adenoma. The total excretion of calcium from the body becomes greater than the total intake, the excess being obtained from the bones (negative calcium balance). The serum content of calcium and of phosphatase is raised, and there is an increase in the calcium and a decrease in the inorganic phosphorus excretion in the urine. The bones undergo osteoclastic resorption of the trabeculæ, and this is accompanied, as is usual when bone is broken down rapidly for any reason, by proliferation of fibrous tissue in the bone marrow.

**Symptoms.** The condition may occur at any age and in any country. The onset is marked by gradually increasing fatigue and aching in the bones. The skeleton softens, the bones become deformed and spontaneous fractures are common ; there is usually marked tenderness to deep pressure over those bones in which changes are most active. The diagnosis is based on the X-ray appearances and the biochemical findings of a raised serum calcium and a negative calcium balance.

**X-rays** (Fig. 336). There is a general decrease in density of the whole skeleton that is slight at first but ultimately becomes extreme. Some bones are affected more severely than others, but the very wide distribution stands in marked contrast to other conditions such as Paget's disease in which some bones always remain normal.

*The cortex of the bones becomes thinner and the margins have a* scalloped appearance at areas where active resorption is in progress. Trabeculæ in the cancellous bone disappear or are replaced by coarse strands arranged in the axis of the bone. There are often localized areas of cystic enlargement somewhat resembling osteoclastomata and usually occurring at places where the bone has been injured.

**Treatment.** Removal of the parathyroid adenoma cures the condition and the bones gradually regain a normal structure. Parathyroid tissue is not confined to the thyroid gland but may occur at a number of situations in the neck and superior mediastinum. An extensive search, which may involve splitting the sternum, is sometimes necessary before the tumour is located.



FIG 336 Hyperparathyroid osteoporosis in a girl aged 18 A parathyroid tumour was removed by Sir G Gordon-Taylor in 1929, the bones recalcified and the patient has since had two children

## HYPERTHYROID OSTEOPOROSIS

Some generalized decalcification of the skeleton commonly occurs in long-standing cases of hyperthyroidism, but as a rule it is trivial in extent and can only be detected in carefully controlled radiographs. Occasionally, however, decalcification is extreme and the cortical bone is reduced in thickness to a mere shell.

The exact reason for the loss of skeletal calcium is not certain. The calcium and inorganic phosphorus content of the serum are within normal limits, but their excretion in both urine and fæces is increased. Control of the metabolic rate by partial thyroidectomy reduces the rate of excretion of calcium and inorganic phosphorus, but it is not as a rule followed by recalcification of bone (Snapper).

The most constant symptom in severe cases is tenderness on deep pressure over the bones. The long bones are readily fractured and the bodies of the vertebræ may collapse. X-rays show decalcification of all bones; the cortex is narrowed but the Haversian canals are not enlarged and the trabeculæ retain their normal arrangement.

Hyperthyroidism in children is accompanied by an increase in thickness of cortical bone and by delay in both the appearance of the epiphyses and the time of the closure of the epiphysial discs.

## HYPERPITUITARISM

The secretion of the cells of the anterior lobe of the pituitary gland influences the growth of the skeleton. Excessive secretion is usually due to a chromophil adenoma of the anterior lobe; in children this causes gigantism, and in adults acromegaly. The syndromes resulting from a deficiency in secretion are not sharply defined but in children there is often obesity and stunting of growth.

### Gigantism

Excessive secretion of the anterior pituitary hormone during the growth period results in a general increase in the growth of all bones. There is an increase in thickness as well as in length and the skeleton remains of more or less normal proportions. Growth at the epiphysial discs is more rapid than usual, and since they also remain open longer, a huge size may be reached (Fig. 337). The bones of the skull are affected, but the facial bones, particularly the mandible, often show a preponderatingly excessive growth. The teeth remain of normal size.

### Acromegaly

Excessive hormonal secretion after the epiphyses have closed causes increased growth only in the thickness of the bones. The more obvious features in a classical case are enlargement of the mandible, the supraorbital ridges, the nose, and the hands and feet (Fig. 338). It is, however, usual for the entire skeleton to be affected to some extent and the vertebræ, the ribs and the tubular bones all become thicker and more massive.

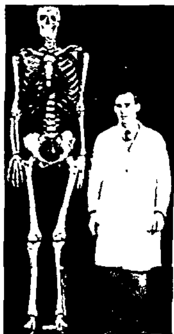


FIG. 337 Skeleton of a man 7ft 7in tall standing beside a man of 5ft 10½in (from the museum of the R C S Eng)



FIG 338 The skull of an acromegalic (from the museum of the R C S Eng)

## PAGET'S DISEASE

(*Synonym*) Osteitis Deformans

This is a condition of unknown ætiology in which the structure of a number of bones, but never of the entire skeleton, is gradually modified. It occurs most frequently in people over forty years of age, but occasionally someone much younger is affected. Sir James Paget, who first described the disease in 1876, considered it to be inflammatory. This view is no longer tenable, and although the real cause is still uncertain, present day opinion inclines to the view that it can be explained on a basis of local hyperæmia, perhaps of metabolic or endocrine origin.

The histological picture is of bone absorption accompanied by somewhat haphazard new bone formation and fibrosis of the bone marrow. Bone formation is more rapid than destruction, hence the bulk of the bone is increased ; but calcification of the new bone is incomplete, so it remains soft. During periods of remission absorption of bone ceases but calcification continues (*osteo-sclerotic type*), and in exceptional cases the bone becomes ivory hard.

### Clinical Features

The onset is very gradual. Sometimes the existence of the disease is revealed in radiographs made for other reasons before there are any symptoms, and sometimes a "spontaneous" fracture is the first indication, but most patients complain of pain or aching in the affected bones for a long time, even before there are any demonstrable radiological changes. In the later stages pain is often a serious feature, and although occasionally the disease is nearly painless throughout its course, most patients suffer from a constant ache deep in the bones ; in a few the pain is so severe as to make life nearly intolerable.

A number of bones may be affected at the same time, and some are involved more often than others ; the order of frequency is spine, sacrum, pelvis, skull, femur, clavicle and tibia (Schmorl). The bones become progressively thicker and they are gradually deformed under the influence of the body weight. When the tibia is affected the increase in size and the exaggeration of its normal curve are conspicuous. Involvement of the skull causes the size of the head to increase gradually making it necessary, so it is said, to get a larger size in hats each year. Deafness due to affection of the petrous bone is common, and this may be the complaint leading to the diagnosis.

Fractures are usually transverse and occur principally in the long bones at sites of stress ; union is not greatly delayed. Incomplete linear fractures on the convex side of curved bones are common (Fig. 340), and compression fractures of the spine are seen occasionally.

The expectation of life is not greatly reduced although occasionally one of the affected bones undergoes sarcomatous degeneration. Many patients live to a ripe old age and are troubled only by increasing deformity and pain.

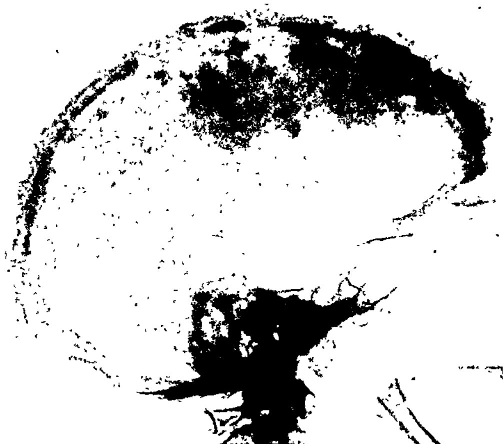


Fig 339. Paget's disease of the skull

**X-rays** (Figs. 339, 340 and 341). The intimate structure of the bone is entirely altered. The cortex is thickened by subperiosteal deposition of new bone and by encroachment on the marrow cavity. The density of the bone is diminished, and the normal trabecular pattern disappears, being replaced by thick, irregular trabeculæ. When the vault of the skull is involved, it becomes thickened and has a "cotton wool" appearance. In the osteosclerotic type the bone is greatly increased in density and has a homogenous structure.

The diagnosis depends on the X-ray appearances and sometimes, especially when the only bones to be involved are one or two vertebræ which have collapsed, it cannot be made immediately.

## Treatment

No treatment at present known has any effect on the course of the disease. The chief clinical problem is the control of pain, and since this arises within bone, little can be done except to administer suitable analgesics. Radiotherapy, in the writer's experience, is without effect. When the bones soften so much that the deformity becomes progressively worse, apparatus such as a weight-relieving caliper or a spinal support may be required. Fractures unite satisfactorily, but rather more slowly than usual.



FIG 340 Paget's disease of the tibia Note the incomplete fractures



FIG 341 Paget's disease, osteosclerotic type.

## LEONTIASIS OSSEA

This is a rare disease in which one or more of the facial bones and the overlying skin are increased in size and thickness. In an extreme instance the whole face is distorted until there may be some slight resemblance to the face of a lion.

There are probably several conditions leading to the same clinical appearance but the ætiology cannot always be determined. Some cases appear to be due to Paget's disease and have an identical histological appearance. In others there is a diffuse osteo-periostitis due to gross dental sepsis; this occurs at a younger age than is usual in Paget's disease, the facial bones are affected instead of the vault of the skull, and the soft tissues may be involved.

## HISTIOCYTOSIS

The more usual form of this rare disease is also known as *lipoid granulomatosis*. It usually occurs during the first two or three decades of life but it has been described in older people. It is characterized by the appearance in the bones of cyst-like spaces filled with granulomatous material in which are islands of "foam cells." The granulomatous tissue consists of proliferating reticulo-endothelial cells and histiocytes; the "foam cells," which are named after their appearance, are histiocytes in which cholesterol esters have been precipitated.



Fig 342 Hand-Schuller-Christian disease (by courtesy of Prof B G Windeyer)

The pathogenesis is uncertain and two possibilities have to be considered (Snapper):—

1. A primary granuloma with secondary infiltration by cholesterol esters. In favour of this are certain cases in which the reticulo-endothelial tissue has proliferated to form a granuloma not containing cholesterol but giving a typical radiological picture.

2. A primary disorder of lipoid metabolism. Against this it is pointed out (*a*) that hypercholesterolæmia is unusual when the lesions are mainly skeletal, but common when they are cutaneous or visceral, and (*b*) that the lesions in bone may not be true xanthomata and can equally well be interpreted as granulomata containing cholesterol deposits.

The bones of the skull are nearly always involved although typical lesions occur in other bones as well, and in rare instances the skull is not affected at all. There are not infrequently deposits in the skin, and occasionally also in the liver and other solid viscera.

The symptoms depend on the distribution of the lesions. Spontaneous fractures are common when the long bones are affected. Radiological diagnosis should be confirmed by biopsy, but a recent lesion must be selected for examination because the cholesterol disappears after a time leaving only fibrous tissue.

*Hand-Schüller-Christian Disease* is an example of histiocytosis with a particular threefold distribution. There are multiple deposits in the flat bones of the skull giving a striking X-ray picture (Fig. 342), deposits in the orbit causing exopthalmos, and deposits in the pituitary fossa which cause diabetes insipidus or infantilism.

**Treatment.** The lesions often disappear with radiotherapy but the effect is only local and other foci appear later elsewhere. Many patients die of intercurrent disease within a few years, particularly when there are visceral deposits.

## Gaucher's Disease

Gaucher's disease is an uncommon familial complaint which as a rule affects one generation only. The underlying pathological condition is the deposition of kerasin, a phosphorus-free lipoid, in the reticulum cells and histiocytes of the spleen, liver, lymph glands and bone marrow ("Gaucher's cells"). Slowly progressive enlargement of the spleen and liver are nearly constant features. The disease commences during the first three decades of life and usually runs a very slow course extending over many years until death occurs from intercurrent disease; occasionally the onset is rapid and the course acute. The cause is unknown and no successful treatment has been discovered.

The characteristic clinical feature is enlargement of the spleen which may reach extreme proportions. As a rule the liver is enlarged also, and frequently there is pigmentation of the skin and conjunctivæ. There are extensive changes in bone marrow caused by infiltration with "Gaucher's cells"; the lower end of the femur is affected more frequently than other bones.

Radiologically the bone is slightly enlarged, the trabecular structure of the cancellous bone is lost and it acquires a moth-eaten appearance; the inner surface of the cortex is eroded, and new bone is deposited under the periosteum (Fig. 343). The diagnosis can usually be made by the identification of "Gaucher's cells" in material obtained by sternal puncture.



FIG. 343 Gaucher's disease (by courtesy of Sir R Watson-Jones).

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FIG 343 Gaucher's disease (by courtesy of Sir R Watson-Jones).

# CONGENITAL DEFECTS OF THE SKELETON

## DIAPHYSIAL ACLASIS

(*Synonyms*) Hereditary Multiple Exostoses, Hereditary Deforming Chondrodysplasia

This is a congenital and often familial disorder of growth in which the growing ends of the long bones fail to model properly. During the normal course of growth newly-formed bone is modelled into cancellous and cortical portions and adjusted to the required external shape; this entails a reduction in breadth from that of the epiphysial discs to that of the shaft (Fig. 344). In diaphysial aclasis the modelling process is at fault and the metaphysial end of bone remains broad and thick, and also gives rise to a number of exostoses. Bones formed entirely within cartilage (i.e. the epiphyses, the carpal and tarsal bones, and the vertebral bodies) and bones formed within membrane are never affected.

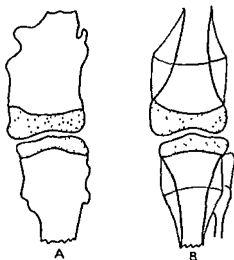



Fig 344 The normal process of modelling during growth (B) does not take place in diaphysial aclasis (A) (after Keith)

The condition affects males more often than females. It manifests itself gradually during childhood or adolescence when the presence of the bony protuberances, and often of deformity, is first noticed. Any of the tubular bones may be involved but most often those around the knee, ankle and shoulder. Sometimes only one or two sites are affected, but frequently both ends of nearly every long bone in the skeleton is distorted and there are literally scores of small exostoses. Bowing of the forearm is a typical deformity; it is caused by the radius growing more rapidly than the ulna, and both the radio-humeral joint and the lower radio-ulnar joint may be dislocated (Fig. 346).

X-rays (Fig. 345) show a typical bulbous deformity, changes in the structure of the metaphysial region of the shaft, and numerous exostoses of varying size.

Treatment is indicated only for the correction of deformity and for the removal of any exostoses which happen to be causing symptoms.



Fig 345. Diaphysial aclasis.



Fig 346. Diaphysial aclasis with bowing of the radius and shortening of the ulna.

## ACHONDROPLASIA

### (*Synonym*) Chondrodystrophia Fœtalis

This is an hereditary condition, probably transmitted as a simple dominant Mendelian characteristic, in which the limbs are short but the trunk is of normal size. The primary cartilage of the affected bones ossifies early, the epiphysial cartilage fails to proliferate normally, and the combined effect is to diminish growth in length. The base of the skull is also affected and fails to grow properly, and since the cranium develops to a normal size, the head has a hydrocephalic appearance.

Achondroplasic dwarfs, the usual dwarfs of the circus, are recognizable clinically by the shortness of the limbs in contrast to the trunk—the hands when hanging by the sides may hardly reach the hips; by the saddle-shaped nose and prominent forehead due to shortening of the base of the skull; by the marked lordosis attributable to alteration in the shape of the pelvis and the position of the acetabulæ; and by the short, stumpy fingers with deviating ring and middle fingers. Mental development is not greatly impaired.

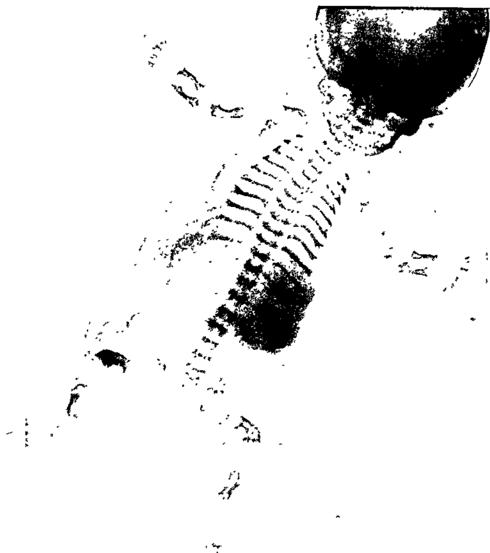


FIG 347 X-ray of a still-born child with achondroplasia

Radiologically the shafts of the long bones are normal in diameter but they are very much shortened, and the bosses where muscles are attached are exaggerated giving an impression of great strength. The epiphyses appear wider than usual and the cortex of the shaft thicker, but neither is actually enlarged and the appearance is due to the altered proportions of the bones. The fibula and ulna are often relatively shorter than the tibia and radius and this causes bowing of the limbs.

## OSTEOPETROSIS

(*Synonyms*) Albers-Schonberg's Disease, Marble Bones

This is a rare condition, sometimes familial, which is probably present at or soon after birth although it may not be diagnosed until later childhood or adult life. The bones are densely calcified but somewhat fragile, and the primary disorder appears to be due to lack of resorption and proper modelling of the internal structure whilst they are still immature. Microscopically,

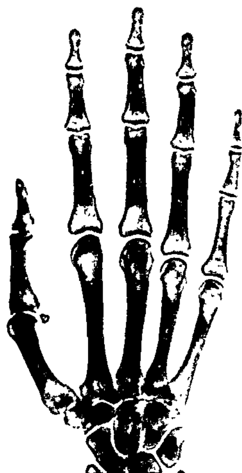


FIG. 348 Osteopetrosis (by courtesy of Mr W D Coltart)

the dense bone consists of intermingled calcified cartilage and primitive immature bone (Weimann and Sicker). The process is often intermittent and this produces rings of dense bone separated by zones of more normal structure.

Radiologically the affected parts of the bones have a dense, homogenous structure. A dense band appears in the metaphysis and seems to travel along the shaft during growth; either the whole of the bone becomes dense, or else dense rings are formed, according to whether the process is continuous or intermittent (Fig. 348). Ring formation in the ilium is a typical feature. The metaphyses may become broad and club-shaped, and the epiphyses are sometimes of irregular density or stippled. The appearance of the vertebræ can be very striking.

The presence of the condition may be revealed by an X-ray taken for an entirely different disorder such as a fracture. In adults the first indication is occasionally severe anæmia caused by the loss of hæmatopoietic marrow. Sometimes the internal auditory meatus and optic foramen are reduced in size and there is interference with hearing and sight. When symptoms become manifest during early childhood the prognosis as regards life is poor.

## OSTEOGENESIS IMPERFECTA

(*Synonyms*) Osteopsathyrosis, Fragilitas Ossium

This is a disease, sometimes familial, in which the bones have an increased fragility and fracture with ease, often as the result of only slight trauma. The bones may also be soft and bend causing striking deformities. In many patients, but not all, the sclerotics of the eyes are blue, and amongst those reaching middle-age otosclerosis is common.

Growth of the bones in length is not as a rule grossly impaired but there may be marked dwarfing caused by bending of the limbs and spine. Growth in thickness is greatly diminished, chiefly because the cortical layer is deficient; there is but a thin cortical shell which often fails to extend the full length of the shaft and leaves an area of cancellous bone near the metaphyses without support (Fig. 349). The deeper layers of the cortex are replaced by cancellous bone in which may be included areas of incompletely calcified osteoid tissue. The medullary cavity may contain an excess of fibrous and fatty tissues.

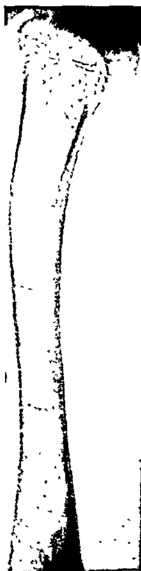


Fig 349 Osteogenesis imperfecta

There are two clinical types which merge with one another. In one type the disorder develops in utero and there are multiple fractures before, during and immediately after birth; in the other type fractures do not commence until later in infancy or childhood, and they occur less frequently. The later in life the disease becomes manifest, the better is the prognosis. Many children fail to survive when the trouble is present at birth, but should they live the bones gradually become stronger and by the time growth has ceased the structure approximates to normal. No specific treatment is known but fractures unite satisfactorily when treated in the usual way. S. L. Baker has pointed out that occasionally hyperplastic callus is formed which bears a close radiological and histological resemblance to sarcoma.

Fairbank recognizes three radiological types:

*Thick bone type* occurring only in severe pre-natal cases. The major long bones are short, thick and broad, although the cortex is thin, and the general appearance somewhat resembles achondroplasia. It is seldom met after three months of age.

*Slender, fragile bone type* which includes pre-natal cases surviving more than a few months, and all post-natal cases. The skeleton as a whole is often osteoporotic, and the long bones may be extremely slender.

*Osteogenesis imperfecta cystica*, a very rare type in which the long bones, in addition to a deficiency in cortex, show a pronounced honeycombed, or cystic, appearance.

## CLEIDOCRANIAL DYSOSTOSIS

This is a rare and often hereditary condition in which the outstanding defects are failure in development of all or part of the clavicles, and delay in closure of the cranial sutures and fontanelles. As a rule the cranial vault is large, the base of the skull and face are small, the milk teeth are stunted and eruption of the second teeth is delayed. In addition individual cases



Fig 350 Cleido-cranial dysostosis (by courtesy of Sir H A T Fairbank)

have been reported in which the pelvis, the femoral neck, and the *metacarpals*, metatarsals and phalanges are also of faulty development. It was formerly thought that only bones formed within membrane were affected, but this view is no longer tenable and the defects may be widespread.

Patients usually suffer remarkably little inconvenience from the absence of clavicles and come to regard the ability to bring their shoulders together in front of the body as a parlour trick.

Fig 351 Dyschondroplasia *Left* in a boy aged 10 *Right* in a woman aged 22



Fig 352 Dysplasia epiphysialis multiplex All the large joints were affected

## DYSPLASIAS OF METAPHYSES AND EPIPHYSES

A variety of conditions in which there is faulty development of the metaphyses, the epiphyses, or both have been described by many authors who have given them almost as great a variety of names. Not infrequently the same condition has been given a succession of names each of which is considered by its originator to be an improvement on the previous ones. Sometimes but a single instance has been recorded, sometimes several cases resemble each other sufficiently to form a definite group, and yet others are common enough to be accepted provisionally as clinical entities. In the course of time, when more individual cases have been published, the grouping of these abnormalities may become clearer. Already achondroplasia, diaphysial aclasis and osteopetrosis, which at one time were included under the general heading of dyschondroplasia, have been separated as genetically distinct abnormalities. It may be that eventually the remaining disorders will either reveal themselves as special instances of a more general defect, or they will be recognized as true entities. A few examples are briefly mentioned below.

### Dyschondroplasia

(*Synonym*) Ollier's Disease

This is the least uncommon of the group, some sixty cases having already been recorded. There is little evidence of heredity. The metaphyses are affected principally, but ossification of the epiphyses may also be irregular. The defect appears to be in the ossification of the growth cartilage, portions of which remain but partly calcified until growth has ceased.

Any of the long bones may be affected, and in about one-third of all cases the distribution is unilateral. The typical radiological appearance is of translucent stripes about one-third of an inch wide running obliquely across the diaphysis (Fig. 351); similar stripes are often seen in the alæ of the iliac bones. There may be a number of translucent zones in the phalanges resembling enchondromata, and many of the cases described as "multiple enchondromatosis" should probably be classified as dyschondroplasia. After the epiphyses have closed irregular calcification takes place and gives the ends of the bones, which are expanded and mis-shapen, a speckled appearance.

Genu valgum due to bending of the lower ends of the femora has been observed on a number of occasions and osteotomy was followed by union in the usual time.

### Dysplasia Epiphysialis Multiplex

This condition, sometimes described as multiple osteochondritis, is one in which the epiphyses appear late, close late and ossify irregularly, sometimes from multiple centres. The epiphyses are irregular in density and shape, and usually they are flatter and less convex than normal (Fig. 352). The limbs are often short and the fingers and thumb strikingly stumpy. The X-ray appearance of the ankle and shoulder is usually the deciding factor in the diagnosis.

## Morquio's Disease

The vertebral bodies are irregular in size and shape, biconvex, narrower from above down, and with a "tongue-like" projection from the anterior surface (Fig. 353). All the long bones including those of the hands and feet may be affected, and the epiphyses may be irregular in shape and stippled. There are many individual variations.





*Left* Fig 353 *Morquio's disease*

*Above*. Fig 354 Osteopoikilosis

## Osteopoikilosis

This condition may or may not be hereditary and probably has no kinship with those already described. The bones are normal in all respects except that they are spattered with ovoid or round islands of dense bone (Fig. 354). It may be found at any age and causes no direct symptoms, although instances associated with other conditions causing symptoms, such as familial dermatofibrosis, have been recorded.

CHAPTER XV

# DISEASES OF THE NERVOUS SYSTEM

## POLIOMYELITIS

(*Synonym*) Infantile Paralysis

Poliomyelitis is an acute disease in which there is widespread infection of the central nervous system. It is caused by a neurotropic virus which has a special affinity for the cells of the anterior horns of the grey matter of the spinal cord. The basal ganglia and cortex are not as a rule affected severely, but occasionally they bear the brunt of the infection.

The changes in the spinal cord are of two kinds; firstly there is an inflammatory reaction around the capillary vessels of the grey matter and diffuse infiltration of the grey matter with polymorphonuclear leukocytes, and secondly there may be degenerative changes in the anterior horn cells. The affected cells may either be put out of action temporarily by pressure of the surrounding œdematous tissues, or they may be destroyed permanently by toxins produced by the action of the virus or as the result of deprivation of their blood supply.

### Epidemiology

The disease occurs in sporadic and epidemic forms. In Great Britain sporadic cases are reported every year in some numbers, mostly between the months of July and October; major epidemics have not yet occurred although from time to time sufficient cases are congregated in one locality to be regarded as a minor epidemic. The 1947 outbreak was of considerable size. In the United States of America the incidence is higher and severe epidemics are frequent.

There is some uncertainty as to the mode of dissemination. Infection can be introduced experimentally into monkeys via the nasopharynx, and it has usually been assumed that the chief mode of spread is by airborne droplet nuclei expelled from the mouths of carriers or infected people during the prodromal and pyrexial stages. A careful investigation by Seddon of the 1942 outbreak in Malta, a most suitable community for such a study because at that time it was isolated, led him to conclude that this was the case in that particular epidemic. The virus can, however, be recovered from human fæces and it may well be that flies, in certain circumstances, are the principal means of dissemination.

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## Prognosis

The prognosis varies with different epidemics, and apparently with different strains of the virus. The mortality is greater amongst adults than children. The usual cause of death is respiratory paralysis, but it may be due to intercurrent disease, particularly in infants who often die of enteritis and marasmus.

There is complete *recovery without any paralysis at any stage in a* large percentage of those surviving the acute phase, the proportion varying from 25 per cent to 75 per cent in different epidemics. Recovery from paralysis depends on whether the anterior horn cells have been damaged temporarily or permanently ; the extent of the initial paralysis, therefore, is not a reliable guide to prognosis, and some patients with severe initial paralysis return almost to normal.

## Clinical Features

Persons of either sex may be affected. The greatest incidence is usually from two to five years of age but it varies in different outbreaks and no age is immune.

There are three distinct clinical phases in the course of the disease :—

Phase of *onset.*
,, ,, *recovery.*
,, ,, *residual paralysis.*

**Phase of Onset.** The reaction to the initial infection varies greatly in different epidemics and in different individuals in the same epidemic. It may be :—

(*a*) *Sub-clinical.* There are no general or local symptoms. Evidence of infection can only be obtained by recovering the virus from the nasopharynx or stools and identifying it by animal inoculation.
(*b*) *Abortive.* An influenzal-like, pyrexial attack of brief duration, and unaccompanied by paralysis. Clinical diagnosis is presumptive and can only be made during an epidemic.
(*c*) *General Symptoms without Paralysis.* The general symptoms resemble those described below and there are identical changes in the cerebrospinal fluid.
(*d*) *General Symptoms with Paralysis.*
(*e*) *Paralysis without General Symptoms.* The patient wakes in the morning unable to move certain muscles or limbs.

The frequency of sub-clinical and abortive attacks is not known but the apparently high immunity of adults in many countries suggests that such attacks are common. It is now generally assumed that a considerable proportion of the population has been infected at some time or other without being aware of it.

General Symptoms. In many instances the onset is marked by symptoms resembling those of any acute infection. The child is feverish, often for only a day, with a temperature of 100° to 101°, and there may be

general malaise, headache, drowsiness, and perhaps diarrhœa and vomiting. Occasionally there is high fever and delirium. Muscular tenderness is usually a prominent feature and is evident early; pain on joint movement also occurs early, probably because this involves movement of muscles, and infants resent handling, nursing, and changing of napkins. At a later stage headache becomes more severe and there is usually pain and stiffness of the back and neck. Somnolence is sometimes marked, anorexia is common, and an initial diarrhœa frequently gives way to obstinate constipation.

Another mode of onset that is fairly often seen, at any rate in Great Britain, is characterized by more gradual development. There is an initial mild fever lasting two or three days, followed by a period of remission of a few days, and then a rather more severe, but indefinite, illness. Muscle pain and tenderness and stiffness of the neck may be delayed a little longer, and paralysis does not appear until perhaps a fortnight after the first symptoms.

The pressure of the cerebro-spinal fluid is raised and the cell count gradually rises to 30–250 per cubic millimetre. At first the increase in cells is shared by both polymorphs and lymphocytes, but the proportion of lymphocytes increases steadily. There is a gradual but moderate rise in both protein and globulin content of the C.S.F.

Paralysis often appears shortly after the general symptoms but it may be delayed for several days, and sometimes, when there has been no general disturbance, paralysis is the first feature to be noticed. Paralysis usually reaches a maximum within a few hours—gradual development is of bad prognosis. It is flaccid in type and may affect a single muscle, a group of muscles, or a complete limb or limbs. Sometimes there is weakness instead of complete paralysis. Paralysed muscles are nearly always tender at first, but by no means all tender muscles become paralysed.

Paralysis characteristically is asymmetrical and patchy; some muscle groups are involved more frequently than others and the distribution varies to some extent with the epidemic. Any spinal segment may be affected but the brunt is usually borne by the lumbar enlargement of the cord (L2—S1), and therefore paralysis is most common in the lower limbs (80 to 90 per cent). The abdominal and spinal muscles are seldom affected alone, but usually in conjunction with the legs. The arms are involved in 30 to 50 per cent of patients, sometimes alone but more frequently at the same time as the legs. The facial muscles are little affected in most epidemics, although with bulbar infection there may be facial, pharyngeal, lingual and occular paralysis.

Diagnosis. Poliomyelitis is seldom diagnosed during the pre-paralytic stage except during an epidemic, but it should be considered in a child or young adult when there is an acute fever of moderate severity accompanied by stiffness of the neck or back. There may or may not be drowsiness, irritability and muscle tenderness. A steady increase in the lymphocyte count and the protein content of the cerebro-spinal fluid is strong presumptive evidence, but it is not absolutely diagnostic. In a doubtful case a certain diagnosis can only be made after animal innoculation of infected material.

# Voluntary Power Chart

| *Number* | *Code* | *Number* | *Code* |
|---|---|---|---|
| 0 | No contraction | 3 | Active movement against gravity |
| 1 | Flicker or trace of contraction. | 4 | Active movement against gravity and resistance |
| 2 | Active movement with gravity eliminated | 5 | Normal power. |

| Right Neck and Trunk | | | | | Left Neck and Trunk | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | *Date of Test* | | | | |
| | | | | Retrocollic Muscles | | | | |
| | | | | Sterno-Mastoid | | | | |
| | | | | (i) Sternal Head | | | | |
| | | | | (ii) Clavicular Head | | | | |
| | | | | Intercostals | | | | |
| | | | | Abdominal Muscles | | | | |
| | | | | Diaphragm | | | | |
| | | | | Erector Spinæ | | | | |
| | | | | Abdominal reflexes | | | | |
| Right Upper Limb | | | | | Left Upper Limb | | | |
| | | | | Trapezius | | | | |
| | | | | Rhomboids | | | | |
| | | | | Pectoralis Major | | | | |
| | | | | Serratus Anterior | | | | |
| | | | | Deltoid | | | | |
| | | | | Adductors of Shoulder | | | | |
| | | | | Int. Rot. of Shoulder | | | | |
| | | | | Ext. Rot. of Shoulder | | | | |
| | | | | Biceps | | | | |
| | | | | Triceps | | | | |
| | | | | Brachio-Radialis | | | | |
| | | | | Ext. Carpi Radialis | | | | |
| | | | | Ext. Communis Dig. | | | | |
| | | | | Ext. Carpi Ulnaris | | | | |
| | | | | Supinator | | | | |
| | | | | Abductor Poll. Long. | | | | |
| | | | | Ext. Pollicis Longus | | | | |
| | | | | Ext. Indicis Proprius | | | | |
| | | | | Pronator Teres | | | | |
| | | | | Flex. Carpi Radialis | | | | |
| | | | | Palmaris Longus | | | | |
| | | | | Flex. Sub. Digitorum | | | | |
| | | | | Flex. Carpi Ulnaris | | | | |
| | | | | Flex. Profundus Dig. | | | | |
| | | | | Flex. Longus Poll. | | | | |
| | | | | Abductor Pollicis | | | | |
| | | | | Opponens Pollicis | | | | |
| | | | | Adductor Pollicis | | | | |
| | | | | Interossei | | | | |
| | | | | Lumbricals | | | | |
| | | | | Reflexes: Biceps | | | | |
| | | | | Reflexes: Supinator | | | | |
| | | | | Reflexes: Triceps | | | | |
| Right Leg | | | | | Left Leg | | | |
| | | | | Hip Flexors | | | | |
| | | | | Hip Extensors | | | | |
| | | | | Hip Abductors | | | | |
| | | | | Hip Adductors | | | | |
| | | | | Int. Rotators of Hip | | | | |
| | | | | Ext. Rotators of Hip | | | | |
| | | | | Quadriceps | | | | |
| | | | | Hamstring Group | | | | |
| | | | | Tibialis Anterior | | | | |
| | | | | Ext. Longus Hallucis | | | | |
| | | | | Ext. Digitorum Longus | | | | |
| | | | | Peronei | | | | |
| | | | | Gastrocnemius | | | | |
| | | | | Flex. Longus Hallucis | | | | |
| | | | | Flex. Digitorum Longus | | | | |
| | | | | Tibialis Posterior | | | | |
| | | | | Intrinsic Foot Muscles | | | | |
| | | | | Reflexes: Knee | | | | |
| | | | | Reflexes: Ankle | | | | |

**Phase of Recovery.** During this phase there is partial or complete recovery of the paralysed muscles; it is unusual for there to be no recovery at all. Improvement usually commences within a week or two; there is seldom much progress until muscle tenderness has diminished, and then there may be a rapid advance for two or three months followed by slow but steady improvement during the next few years. It is very unlikely that a severely paralysed muscle which has failed to show any sign of recovery during the first few months will subsequently gain useful power. Although recovery is spontaneous, careful treatment at this stage is essential to ensure the greatest possible gain in power and co-ordination, and to prevent contractures.

**Phase of Residual Paralysis.** With good treatment the condition is likely to become stationary within two years and no further improvement can be looked for. The problem then is to provide the best possible function with the help of operation and apparatus, and to help the patient to adapt his life to his altered physical condition.

## Treatment

Before commencing treatment it is essential to record accurately the precise extent of muscle weakness and paralysis. This is of importance in determining the prognosis and in deciding the earliest moment at which operative interference is desirable. It is not sufficient just to note, say, "foot-drop," but each muscle must be examined separately. The method of recording muscle power has been standardized in Great Britain by the Medical Research Council and this should always be used so that records made at home will be of value if the patient is later transferred to hospital. Progress should be charted at regular intervals.

**Phase of Onset.** During an epidemic all mild feverish illnesses may be regarded as due to poliomyelitis until the contrary is proved. Infectivity is thought to be greatest during the pre-paralytic phase and therefore isolation is advised, particularly from contact with young children. Special precautions should be taken with the disposal of fæces, used handkerchiefs, etc.

The chief therapeutic indication is rest and the patient should be kept strictly in bed even if there is no paralysis. Sedatives may be necessary for the relief of pain and to ensure rest. Aperients are required if constipation is troublesome but treatment should not be allowed to cause undue disturbance. The mattress must be firm, and if necessary supported by "fracture boards." Weak or paralysed limbs should be prevented from moving by sand-bags or light splints, the hips and knees being slightly flexed, the feet supported, and the shoulders abducted and in neutral rotation. At first rest is more important than accurate splinting and the latter can be postponed for a few days. Hot fomentations help to relieve muscle pain, but massage does more harm than good at this stage.

Paralysis of the respiratory muscles may require special attention. Atropine is given to diminish secretion. A mild degree of respiratory embarrassment can be alleviated by raising the head of the bed, but gross

respiratory failure may develop very rapidly and the nurse should be warned that, if it does, artificial respiration must be commenced manually whilst a mechanical respirator is being prepared.

SERUM. It is well established that the serum of convalescent patients contains antibodies capable of neutralizing the virus in vitro. There is, however, no acceptable evidence that the administration of serum either before or after the onset of paralysis has any influence on the course of the disease. Nevertheless serum is sometimes given, the dosage recommended being 20 cc. intrathecally plus 30 cc. intravenously for a child aged two to three years, and rather more for older children. It is possible that serum confers temporary passive immunity if given before exposure to infection, or during the period of incubation.

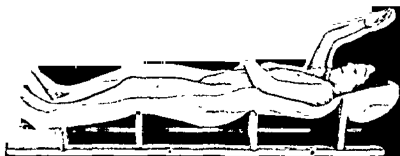


FIG. 355

**Phase of Recovery.** More active treatment is commenced as soon as the general symptoms have subsided and muscle tenderness has become less. It is important to begin early, if possible within a week of the onset of paralysis.

SUPPORT. This is necessary to prevent deformity and to rest weak or paralysed muscles. The general requirements are that the support should be so arranged that paralysed muscles are held at an intermediate point in their range of movements, and that active and passive movements are possible without removing it.

The exact nature of the support varies with the extent of the paralysis. If it is widespread and includes the muscles of the buttocks, back or abdomen, a plaster bed is very satisfactory. It has the advantage of being able to accommodate all four limbs, it is comfortable, and it allows active movements of unparalysed muscles (Fig. 355). A single extremity without involvement of hip or shoulder is conveniently supported on a plaster shell.

The position in plaster plays an important part in determining subsequent function and must be arranged with meticulous care. The spine requires the same curves as when standing; the hips and knees should be slightly flexed, the ankles at right angles with the legs and the feet plantigrade, neither inverted or everted; the arms should be abducted about 70° in the scapular plane and in neutral rotation; the elbow is at a right angle, the wrist is slightly dorsiflexed, the fingers are placed in the position of rest and the thumbs partly opposed.

Movement. Commencing as early as possible, every joint should be gently moved once daily through its greatest painless range. This is an important feature of early treatment and has the object of preventing joints from becoming stiff and muscles from deteriorating.

Active contraction of affected muscles is encouraged but excessive fatigue must be avoided. At first a muscle may give a flicker once or twice but repetition is impossible until after a long rest: later it may move the joint whilst the weight of the limb is supported, and later still move it against gravity. Whatever the power of the muscle, exercise must be arranged to suit its strength, and it must be followed by a period of rest long enough to allow it to recover from fatigue. Trick movements should be watched for and care taken to encourage use of the proper muscles instead. Immersion in water during exercise is of great value because it counteracts the effect of gravity.

Co-ordination of movement and "awareness" of certain muscles appear to be lost in some patients, perhaps because of damage to communicating fibres within the spinal cord. Deliberate exercises in co-ordination may, therefore, be required. A muscle over which there is no direct voluntary control will often contract when used as a synergist and advantage should be taken of this.

Passive Physiotherapy is of assistance in maintaining the nutrition of very weak or paralysed muscles. Muscles function better when warm than cold and therefore they may be gently heated before exercise. Massage improves both venous and lymphatic circulation but it should not be carried out roughly, nor for too long, or it may damage muscle fibres. Electrical stimulation may also be helpful. A paralysed muscle loses its response to faradism but reacts to galvanism and therefore interrupted galvanic stimulation is a useful form of exercise.

Progress. No precise rules can be given as to the time when sitting up or walking may begin because of the great individual variation in the severity and distribution of paralysis. Every muscle with power less than that necessary to contract against resistance requires support until maximum recovery has occurred; this is difficult to arrange in an ambulant patient, except when paralysis is limited in extent, and therefore many patients have to remain recumbent for several months. When only one lower limb is affected, however, walking may be possible fairly early using crutches and a light plaster splint; the upper limbs can be supported on splints or by means of a plaster spica; and the abdominal muscles must be protected by a well-fitting cloth corset if they show any sign of weakness.

Support for the trunk is very important when the erector spinæ are paralysed, especially in children, in order to prevent the development of scoliosis. There is no really efficient splint or jacket and therefore recumbency has to be continued for a much longer period. If a plaster bed is being used, a turning case should be provided to facilitate exercises.

Whether the patient is ambulant or recumbent, treatment under skilled supervision must be continued until maximum recovery has taken place; this is often as long as two or three years and sometimes even longer.

respiratory failure may develop very rapidly and the nurse should be warned that, if it does, artificial respiration must be commenced manually whilst a mechanical respirator is being prepared.

SERUM. It is well established that the serum of convalescent patients contains antibodies capable of neutralizing the virus in vitro. There is, however, no acceptable evidence that the administration of serum either before or after the onset of paralysis has any influence on the course of the disease. Nevertheless serum is sometimes given, the dosage recommended being 20 cc. intrathecally plus 30 cc. intravenously for a child aged two to three years, and rather more for older children. It is possible that serum confers temporary passive immunity if given before exposure to infection, or during the period of incubation.

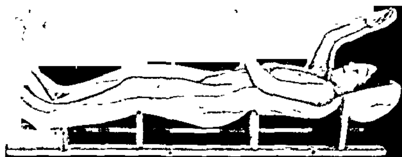


FIG. 355.

**Phase of Recovery.** More active treatment is commenced as soon as the general symptoms have subsided and muscle tenderness has become less. It is important to begin early, if possible within a week of the onset of paralysis.

SUPPORT. This is necessary to prevent deformity and to rest weak or paralysed muscles. The general requirements are that the support should *be so arranged that paralysed muscles are held at an intermediate point in* their range of movements, and that active and passive movements are possible without removing it.

The exact nature of the support varies with the extent of the paralysis. If it is widespread and includes the muscles of the buttocks, back or abdomen, a plaster bed is very satisfactory. It has the advantage of being able to accommodate all four limbs, it is comfortable, and it allows active movements of unparalysed muscles (Fig. 355). A single extremity without involvement of hip or shoulder is conveniently supported on a plaster shell.

The position in plaster plays an important part in determining subsequent function and must be arranged with meticulous care. The spine requires the same curves as when standing; the hips and knees should be slightly flexed, the ankles at right angles with the legs and the feet plantigrade, neither inverted or everted; the arms should be abducted about 70° in the scapular plane and in neutral rotation; the elbow is at a right angle, the wrist is slightly dorsiflexed, the fingers are placed in the position of rest and the thumbs partly opposed.

stage by adaptive changes in the shape of the bones. A deformity due to relative shortness of a partly paralysed muscle can sometimes be improved by repeated forcible stretching after administering curare.

**Spine.** Scoliosis is a common sequel to weakness or paralysis of the muscles of the back or abdomen, particularly when unilateral. In children, the deformity tends to increase during growth and may become very severe. It is probable that "idiopathic" scoliosis is often due to undiagnosed poliomyelitis (p. 88).

Scoliosis is often rather late in developing and is easily overlooked in the early stages. Once the shape of the bones has changed it is impossible to correct it; prophylaxis is therefore most important and a spinal or abdominal support is necessary whenever the muscles of the trunk are involved. The support must be worn until growth of the spine has ceased at about fourteen years of age, and then spinal fusion may be considered. Developed scoliosis is treated in the same way as when it is due to other causes (p. 92).

**Hip.** Flexion-adduction deformity occasionally results from paralysis of the gluteus maximus, and when all the glutei are paralysed the hip may dislocate backwards. A mild degree of flexion deformity can be overcome by stretching, but a more severe contraction may require correction by *Soutter's fasciotomy.* In this operation the fascia femoris is divided and the muscles on both surfaces of the anterior portion of the ilium are detached subperiosteally and allowed to slide downwards. Dislocation of the hip may be controlled by construction of an artificial check ligament (*Ober*), and several other operations.

**Knee.** Various deformities may occur. Flexion deformity due to overaction of the hamstrings and gastrocnemei can usually be straightened by traction or by a wedged plaster. Hyperextension due to weakness of the flexors is a serious disability; it is not satisfactorily treated by operation and a caliper may be necessary. Genu valgum is not uncommon, and if severe it may need correction by osteotomy (p. 29).

**Foot and Ankle.** Pes equinus, probably the commonest of all paralytic deformities, is due to paralysis or weakness of the dorsi-flexors of the foot and relative overaction of the calf muscles. The deformity is easily corrected by lengthening the tendo-Achillis but this must not be done if the knee is unstable. Many patients whose quadriceps are paralysed are able to walk without apparatus by bracing the leg against an equinus foot.

A varus or valgus deformity may require temporary control by a walking iron (Fig. 357), but permanent correction by one of the stabilizing operations should be carried out as soon as practicable (p. 464). Pes cavus develops when the intrinsic muscles of the foot are paralysed and the long flexors and extensors remain in action. A severe degree of cavus is most difficult to correct, but arthrodesis of the interphalangeal joints of the toes, if done early, may prevent it developing (Lambrinudi's operation, p. 230).

**Upper Limb.** Fixed deformities, except at the shoulder, are seldom seen and they do not conform to standard types. Adduction-internal

Exercise is carefully graduated to develop the weaker muscles. A swimming pool, or if this is not available, suspension by springs or by weights and pulleys, are of value when exercising weak muscles because the force of gravity is reduced (Fig. 356). It is most important to plan exercises with special regard to muscle balance because, if the patient is left to himself, he naturally uses the stronger muscles which then develop at the expense of the weaker ones, and imbalance is increased.

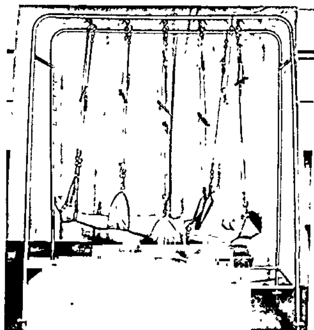


Fig 356 Guthrie-Smith suspension frame

The final result, provided the destruction of nervous tissue is not too great, depends to no small extent on the perseverance of the patient. The way in which some apparently hopelessly paralysed people make use of the little power they have is so remarkable that it should never be forgotten by those in charge of them. The patient must not be allowed to despair however dreadful his disability may seem, but he must be treated in an atmosphere of encouragement and cheer, guided through the difficult early days, and taught to understand the way in which he can best help himself.

## Deformity

Deformity can be caused by (1) overaction of unopposed muscles, (2) relative shortening of paralysed muscles and (3) weight-bearing on a partly paralysed limb. It should, however, seldom occur when treatment is carried out in proper conditions and is competently supervised, except perhaps at the spine which is difficult to support by mechanical means.

Some deformities, such as genu recurvatum, are associated with lengthening of the soft tissues and the joint is hypermobile. In the majority, however, the deformity is fixed by soft tissue contraction, and at a later

unless the quadriceps are strong. As a rule, when the knee and ankle are flail as well as the hip, it is best to accept the limp and control the knee and foot with irons. Occasionally *Ober's operation* may be feasible; the fascia femoris is detached at the lower end, passed through a hole cut in the upper end of the femur and attached to the erector spinæ which are thus enabled to act as abductors of the hip.



FIG 357 Short inside iron and outside T-strap to control pes varus.

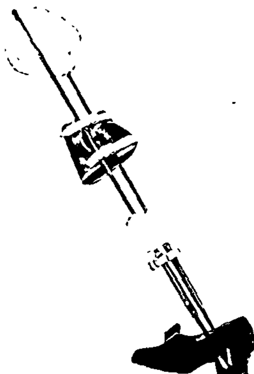


FIG 358 Long double irons with round socket in heel and ankle stop at 90°.

**Knee and Foot.** The gait, if only one leg is affected, is reasonably good when the knee and foot are controlled by irons. It is often possible, however, to dispense with apparatus, even when both legs are involved, by stabilizing the foot in equinus (see below).

**Knee.** Paralysis of the quadriceps causes surprisingly little disability provided there is some fixed equinus against which the leg can be braced. The glutei, when reasonably strong, are used to brace back the thigh thus fixing the knee, and there is hardly any limp; when the glutei are weak, the trunk is thrown a little forwards when walking and then the knee is forced backwards and locked because the centre of gravity of the body is in front of the joint (Fig. 3, p. 4). Although it is unusual for apparatus to be necessary when only the knees are affected—I have a patient with bilateral flail knees and stabilized feet who dances excellently—sufficient stability cannot always be acquired without assistance and then leg irons with a knee hinge and lock can be supplied. With unilateral paralysis arthrodesis of the knee is sometimes desirable, and occasionally transplantation of the hamstrings into the patella is worth while.

rotation deformity of the shoulder is sometimes troublesome and may be overcome by repeated passive stretching or by operation (p. 475).

## Residual Paralysis

The assessment of a patient at this stage is a responsibility needing a wide knowledge both of the mechanics of the human body and of the many different kinds of stabilizing operations and apparatus. Maximum motor recovery has taken place, or at any rate the possibilities of further improvement are defined, and the problem is to enable the patient to make the greatest possible use of the remaining muscle power.

It is not always necessary to await maximum recovery before embarking on stabilizing operations provided the patient is old enough for arthrodesis to be practicable, say twelve to fourteen years of age. A muscle that shows no recovery or only a flicker of movement after, say, six months is unlikely ever to become strong enough for heavy work and it saves the patient's time to arrive at an early decision. For example, if the invertors of the foot are paralysed, the foot goes into extreme valgus when standing and the sooner it is stabilized the better because the immediate improvement in function enables the patient to concentrate on other and more difficult problems. But if the muscles of the hand are weak, the decision to operate should be postponed for as long as there is hope of improvement.

Three methods of stabilizing joints and redistributing muscle power are available for use separately or in combination—*apparatus, arthrodesis* and *tendon transplantion*. Much ingenuity has been displayed in evolving different uses for tendon transplantation, and although they are of great value for an occasional patient, few have proved successful enough for general service. In Great Britain the use of transplants is more or less restricted to the hand; for the lower limb arthrodesis is more popular because it usually gives a better functional result. Detailed description of the many possible procedures is outside the scope of this book and only the general lines of some of the commoner ones will be indicated.

**Spine.** The approach, whether by apparatus or operation, is similar to that for scoliosis in general but the paralytic spine is more easily supported by apparatus (p. 92).

**Hips, Knees and Feet.** *Bilateral.* Almost every patient whose arms are good enough to use crutches can be made ambulant, even when there is complete paralysis of both lower limbs. The knees are held straight by long double irons with an ankle stop to control foot drop (Fig. 358), if the spinal muscles also are weak, a spinal support is provided, and then "tripod" walking is possible with the aid of two crutches. Progression by this method is slow, but at least it is possible for the patient to get about the house alone. Stabilizing operations are seldom worth while.

*Unilateral.* Absence of the glutei causes a gross "Trendelberg limp" which is very difficult to prevent (p. 119). Leg irons can be attached to a pelvic band or spinal support by means of a hinge at the hip, but this is seldom satisfactory. Arthrodesis of the hip does not give good function

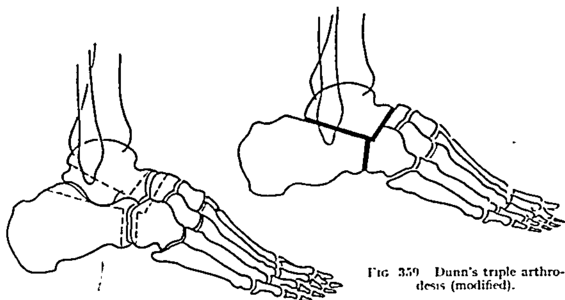


Fig 359 Dunn's triple arthrodesis (modified).

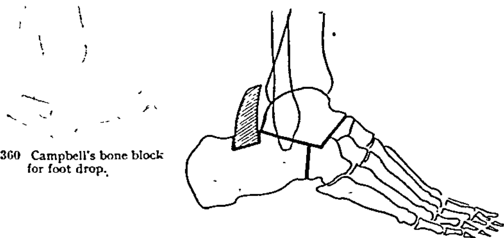


Fig 360 Campbell's bone block for foot drop.

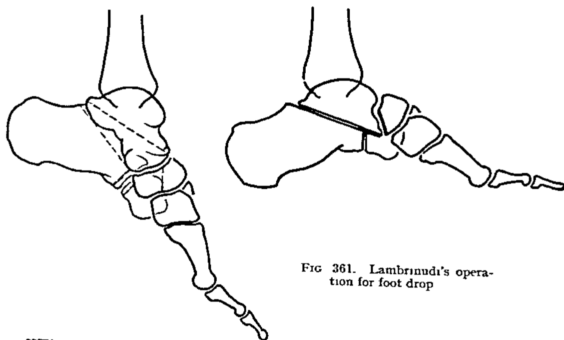


Fig 361. Lambrinudi's operation for foot drop

**Foot.** Stabilization of the foot is a really satisfactory operation giving good function and practically no limp. It is indicated when there is paralysis of the invertors causing a valgus foot, paralysis of the evertors causing a varus foot, and when the foot and ankle are flail.

The several operations in common use are all based on the classical prototypes described by Dunn in England and Hoke in the U.S.A. *Dunn's operation* is a triple arthrodesis in which the talo-calcanean and calcaneo-cuboid joints are fused and the entire navicular is removed, the talus being joined to the cuneiforms. Most surgeons prefer not to remove the navicular and fuse the talo-navicular joint instead (Fig. 359). The same object may be achieved, provided the ankle is not flail, by the more modern *method of fusing the joints with cancellous grafts* (p. 216)

When the ankle is flail Dunn's operation requires modification in such a way as to limit foot drop and yet permit dorsi-flexion at the ankle. The desirable range of movements depends on the height of heel customarily worn and on whether the knee is flail; in the latter case some fixed equinus must be provided. In *Lambrinudi's operation* a wedge of bone of the required size is excised from the talus and calcaneus and this enables the necessary range of movements to be provided with accuracy (Fig. 361).

Other procedures having the same objective, such as *Campbell's operation*, involve first a triple arthrodesis, and then checking foot drop by means of bone graft placed on the upper surface of the posterior end of the calcaneous (Fig. 360).

**Upper Limb.** The value of the upper limb depends principally on the function of the hand, and as long as movement of one finger remains, the hand can be made of some use. It is, however, necessary for the hand to be moved to the object to be grasped and therefore, if the shoulder and elbow are flail, they must be stabilized.

**Shoulder.** Arthrodesis is a most useful operation when the muscles controlling the scapula are reasonably strong (p. 295).

**Elbow.** Stabilization may be effected either by arthrodesis or by an arm corset with a hinge that enables the joint to be locked in any position (Fig. 242, p. 310). Arthrodesis is usually more satisfactory when the muscles of the shoulder are strong enough to control it, but a corset is better when the shoulder has been arthrodesed.

**Hand.** The possibilities depend on the available muscle power. The essential requirements are active flexion of at least one finger, preferably the forefinger, and a "post" against which the finger can press. If all the flexors of the fingers are paralysed, it may be possible to supply motor power by transplanting one of the flexors of the wrist. The best "post" is an opposable thumb, and if a suitable muscle is available, a tendon transplant can be performed to provide active opposition; if no muscle is available, the thumb may be fixed in opposition by means of a bone graft placed between the first and second metacarpals. It may be desirable to arthrodese the wrist in slight dorsi-flexion (p. 332). When paralysis is limited to the intrinsic muscles and there is a claw hand, *Bunnell's operation* is successful (p. 330).

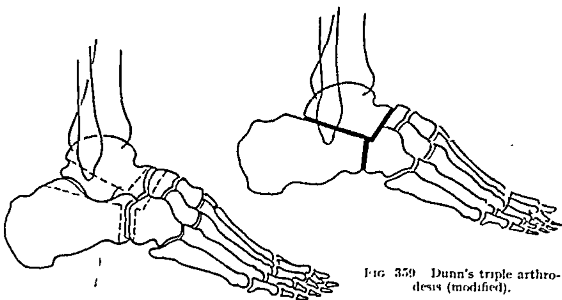


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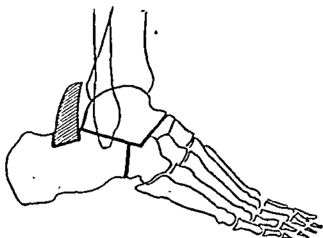


Fig. 360 Campbell's bone block for foot drop.

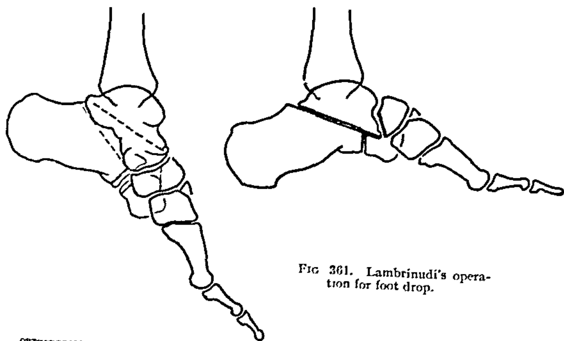


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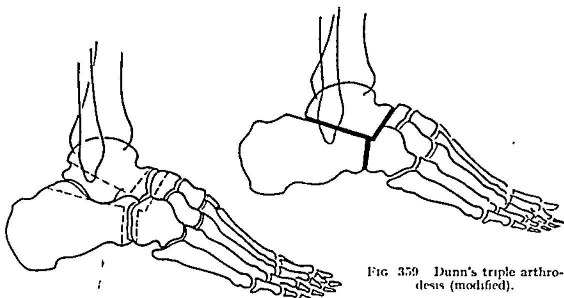


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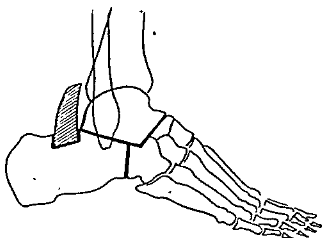


FIG 360 Campbell's bone block for foot drop.

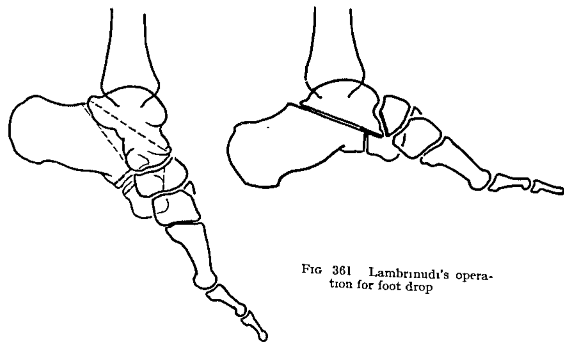


FIG 361 Lambrinudi's operation for foot drop

## SPASTIC PARALYSIS

(*Synonyms*) Little's Disease, Cerebral Paralysis of Children, Cerebral Diplegia, Congenital Diplegia

*Paralysis is a misnomer.* The term "spastic paralysis" is applied to a heterogenous group in which there is disturbance of the locomotor system with hypertonia of the muscles, occasionally hypotonia, often athetosis, but never paralysis. The condition is present at or soon after birth and is due to a lesion of the cerebral cortex or basal ganglia causing a disorder of upper motor neurone type. The precise symptoms vary with the extent and distribution of the lesions and include spasticity, involuntary movements and mental defects.

Different names are applied according to the region affected :—

| | |
|---|---|
| One extremity. | *Monoplegia.* |
| Half the body. | *Hemiplegia.* |
| Both legs. | *Paraplegia.* |
| Both legs and arms. | *Diplegia* or *quadriplegia.* |

The ætiology has been much disputed. Of the several theories advanced at different times, the following are usually accepted :—

ANTE-NATAL—Rare. Early arrest in fœtal development.

NATAL—Common. Birth injury causing meningeal hæmorrhage is probably the cause in most instances.

POST-NATAL—Uncommon. Thrombosis, meningitis, or encephalitis.

### Clinical Features

The symptoms vary with the distribution of the degenerative changes in the brain. They fall into four distinct groups which, however, are often mixed.

PRE-FRONTAL CONVOLUTIONS. Mental defects which vary in degree from slight backwardness to idiocy.

PRE-CENTRAL CONVOLUTIONS. Defects of motility. There is spasticity of the lower limbs and often of the upper limbs also. Very occasionally there is hypotonia affecting the limbs, the back and the neck.

BASAL GANGLIA. Uncontrolled athetoid movements of the affected limbs, usually more marked in the arms than the legs. Athetosis is exaggerated on attempting voluntary movements and during emotional stress, and it is usually absent during sleep.

CEREBELLUM. Rare. Ataxy of cerebellar type.

Phelps has drawn attention to a condition of pseudo-spasticity, or "athetosis with tension," which occurs as the result of spontaneous efforts to control involuntary movements. The limbs are held rigid in the attempt to keep them still, and in the course of time a condition develops which is indistinguishable on casual examination from true spasticity. The differential diagnosis between true spasticity and athetosis with tension,

which is most important because the prognosis is better in athetotics, is discussed under treatment.

**Spasticity.** The distribution is usually symmetrical and more marked in the lower than the upper limbs: occasionally it is greater on one side of the body than the other. The tendon reflexes are generally increased and the plantar responses upgoing. The affected limbs are held rigid, often in a distorted position, and they are used with difficulty even when muscle power is reasonably good. The degree of spasticity varies from slight awkwardness in the use of the limbs to gross rigidity in which voluntary movement is impossible.

The appearance when well developed is characteristic (Fig. 362). The lower limbs are held with the hips flexed, adducted and internally rotated, the knees may be extended or partly flexed, and the feet are in strong equinus. When both legs are affected the knees are pressed together, or one leg is crossed over the other, making walking very difficult (scissors gait). The upper limb in a severe case is held with the shoulder adducted and internally rotated, the elbow flexed, the forearm pronated, the thumb opposed and the fingers flexed over the thumb. Lordosis is common because of flexion of the hips and spasm of the erector spinæ, and there is often some scoliosis because the power of the spinal muscles of the two sides is unequal. The face may be expressionless, and in a hemiplegic it is asymmetrical.



FIG 362. Spastic paralysis showing "scissor legs" and athetoid movements of the hands

**Athetosis.** Athetoid movement is present in at least a quarter of all patients, and probably in many more because of the frequency with which it is masked by muscle tension. It is usually more marked in the arms than the legs, and it is more in evidence when there is little spasticity. The arms are affected by slow, sinuous twisting movements, irregular, arrhythmical and of considerable range. The movements are worse when attempting to control them and during deliberate voluntary actions. If the legs are affected, it is difficult to place the feet accurately when walking and the gait is unsteady. Speech may be disturbed, deglutition uncertain, and even when the face is ordinarily expressionless, there may be attacks of involuntary laughing or crying.

**Mental Development.** There is frequently some degree of mental impairment although it may be comparatively slight and interfere but little with education. Unfortunately the mental defect is often more serious and many children can be taught to walk and keep themselves clean only

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Fig. 362. [illegible] showing [illegible] affected [illegible] hands.

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| Half the body. | *Hemiplegia.* |
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**Spasticity.** The distribution is usually symmetrical and more marked in the lower than the upper limbs; occasionally it is greater on one side of the body than the other. The tendon reflexes are generally increased and the plantar responses upgoing. The affected limbs are held rigid, often in a distorted position, and they are used with difficulty even when muscle power is reasonably good. The degree of spasticity varies from slight awkwardness in the use of the limbs to gross rigidity in which voluntary movement is impossible.

The appearance when well developed is characteristic (Fig. 362). The lower limbs are held with the hips flexed, adducted and internally rotated, the knees may be extended or partly flexed, and the feet are in strong equinus. When both legs are affected the knees are pressed together, or one leg is crossed over the other, making walking very difficult (scissors gait). The upper limb in a severe case is held with the shoulder adducted and internally rotated, the elbow flexed, the forearm pronated, the thumb opposed and the fingers flexed over the thumb. Lordosis is common because of flexion of the hips and spasm of the erector spinæ, and there is often some scoliosis because the power of the spinal muscles of the two sides is unequal. The face may be expressionless, and in a hemiplegic it is asymmetrical.



FIG. 362. Spastic paralysis showing "scissor legs" and athetoid movements of the hands

**Athetosis.** Athetoid movement is present in at least a quarter of all patients, and probably in many more because of the frequency with which it is masked by muscle tension. It is usually more marked in the arms than the legs, and it is more in evidence when there is little spasticity. The arms are affected by slow, sinuous twisting movements, irregular, arrhythmical and of considerable range. The movements are worse when attempting to control them and during deliberate voluntary actions. If the legs are affected, it is difficult to place the feet accurately when walking and the gait is unsteady. Speech may be disturbed, deglutition uncertain, and even when the face is ordinarily expressionless, there may be attacks of involuntary laughing or crying.

**Mental Development.** There is frequently some degree of mental impairment although it may be comparatively slight and interfere but little with education. Unfortunately the mental defect is often more serious and many children can be taught to walk and keep themselves clean only

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Accurate estimation of intelligence is of great importance but it is difficult because the physical defects may interfere with routine tests. Only the more intelligent respond well to treatment which is both elaborate and lengthy. The intermediate grades can usually be taught to walk and look after themselves by comparatively simple measures, but they do not benefit from more advanced education ; the least intelligent are not proper subjects even for surgical treatment.

## Diagnosis

During the first three months of life nothing abnormal is noticeable unless there is gross mental defect. The earliest indication of trouble is often a delay in the normal sequence of physical development. The baby does not, as is usual, raise its head at about three months, nor sit up at six months ; it does not begin to walk and talk until late, and control of the sphincters is delayed.

Spasticity is demonstrated in an infant by lifting it by the axillæ ; the normal child draws up the legs, but the spastic extends and perhaps crosses them. Spasticity in older children is recognized by the characteristic resistance to passive flexion ; there is difficulty in commencing the movement, but the spasm suddenly gives way and the rest of the range is free. Involuntary movements often do not appear until two or three years of age.

In spastic paralysis of spinal origin, which also may be the result of birth injury, the affection is bilateral and symmetrical. There is usually pain at some stage, impairment of sensation, and often trophic changes in the limbs.

## Treatment

**Non-operative.** Little change has been noticeable in our conception of spastic paralysis, or in its treatment, since the time over 100 years ago when W. J. Little, who took so much interest in the disease, himself underwent a tenotomy (for club foot). Since then it has been customary to correct deformities by tenotomy, and more recently, with the intention of reducing the power of muscles in spasm, by neurectomy also ; re-education filled only a secondary rôle. This attitude has been challenged by Phelps of Baltimore who has shown that many patients are not suffering from true spasm of pyramidal origin, but a state of "athetosis with tension" which is distinguished from it only with difficulty. Mental defects are usually less severe in this group, the prognosis is rather better, and comparatively few cannot be educated.

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apparent during treatment because conscious relaxation, which plays an important part in it, releases the involuntary movements.

Segregation during treatment is highly desirable because the emotional atmosphere is controlled, and because it is necessary to have the co-operation of many special workers who can hardly be made available except in an institution. The therapeutic team is headed by a medical officer and consists of physiotherapist, educational psychologist, occupational therapist, speech therapist and teacher. It is said that ideally the number of staff should be several times greater than the number of patients. Parents of patients may be encouraged to take a place in the life of the community and so become familiar with the methods and continue the training after discharge.

*The feature of prime importance is the acquisition of the power of* conscious and voluntary relaxation. Relaxation is at first learned lying down, and then with gradual progression to sitting, standing with support and finally walking. Movements, for example feeding, are made during relaxation without regard for the interference caused by involuntary movements. Advantage is taken of the reflex inhibition of an antagonist muscle which occurs during active contraction of the agonist. Muscle control is learned gradually as confidence is gained, and the weaker muscles, for example the abductors and external rotators of the hips and the supinators of the forearm, are deliberately developed. Exercises are more readily performed if carried out rhythmically.

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The administration of curare in oil, which is absorbed slowly, has been favourably reported on. It is thought that a certain dosage has a selective action which prevents abnormal motor impulses crossing the neuro-muscular junctions without interfering with the conduction of normal impulses.

**Operative.** Non-operative measures give the best results in selected patients, but a great many are in an intermediate group and are neither intelligent enough to benefit from elaborate education, nor of so low a grade as to be untreatable. Most of these can be helped by a combination of simpler educative measures along the general lines already described, and operation when they get older.

There are two types of operation in common use—tenotomy to correct contractures, and neurectomy to reduce the power of spastic muscles.

TENOTOMY, or tendon lengthening, is indicated when a spastic muscle has contracted to such an extent that the joint is held in a distorted position even when the muscle is relaxed. It is of less value when there is a good range of movement during relaxation because continued spasm eventually "takes up the slack," and the deformity returns. During examination spasm can usually be overcome by firm steady pressure, but deep anæsthesia is sometimes necessary to obtain full relaxation. The periarticular tissues may be contracted and require division as well as the tendon.

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The usual deformities that require correction by tenotomy are :—

*Equinus Deformity of the Foot.* Lengthening the tendo-Achillis by open operation gives more consistent results than closed tenotomy. The posterior capsule of the ankle joint may also require division.

*Flexion Contracture of the Knee.* This can be corrected by lengthening the hamstrings and, if necessary, posterior capsulotomy (p. 192).

*Adduction of the Hip.* The adductors are readily tenotomized close to their origin from the pelvis.

*Internal Rotation of the Hip.* If adductor tenotomy gives insufficient correction, the gluteus medius and tensor fascia femoris may be detached from the ilium and allowed to slide lower down.

*Internal Rotation of the Shoulder.* Benefit is sometimes derived from division of the pectorals, and in very severe deformities division of the subscapularis also.

NEURECTOMY. (*Stoffel's operation.*) This procedure is used to restore muscle balance by eliminating spastic muscles, or a sufficient proportion of their fibres to enable the weaker, opposing muscles to overcome their resistance. It is moderately successful in selected patients when spasm is not too severe, and when some co-operation in after-treatment can be obtained. Operation should be preceded by correction of contractures, and followed by prolonged re-education.

*Obturator Nerve* for adductor spasm. Obturator neurectomy is the most useful of the operations of this type and may materially improve the gait when it is impeded by adductor spasm. The entire obturator nerve can safely be divided because it supplies only part of the adductors ; there is sufficient power of adduction in the remaining parts which are supplied by branches of the sciatic and femoral nerves.

The obturator nerve is conveniently exposed by an extra-peritoneal approach and divided as it lies on the inner wall of the pelvis before entering the obturator foramen. It can also be exposed by dissection in the groin where the anterior branch, the posterior branch, or both may be divided.

*Sciatic Nerve* for spasm of the hamstrings. The portion of the nerve supplying long head of biceps, semimembranosus and semitendinosus forms a separate bundle which lies, in the upper part of the thigh, on the inner side of the nerve. The component elements of this bundle are identified by electrical stimulation ; it is usual to divide completely those portions supplying the long head of biceps and the semimembranosus, and part of the supply to the semitendinosus.

*Internal Popliteal Nerve* for spasm of the calf muscles causing pes equinus. The nerve is exposed in the popliteal space and the three branches supplying the inner and outer heads of the gastrocnemius and the posterior portion of the soleus are identified and divided.

*Median Nerve* for flexion of the elbow and pronation of the forearm. The nerve is exposed in front of the elbow ; the bundle supplying the pronator radii teres, the flexor carpi radialis and the palmaris longus lies on the anterior surface and may be completely or partly divided.

## ADULT HEMIPLEGIA

Adults with hemiplegia of cerebral origin only too frequently lie around in institutions or in their own homes without treatment, and they rapidly develop crippling contractures and lose all interest in life. The condition in many respects resembles spastic paralysis of children and, up to a point, it is amenable to similar treatment. Much can be done by painstaking re-education, particularly if it is carried out in cheerful surroundings amongst other patients who are imbued with hope, instead of being consumed with despair as is so often the case.

Operative correction of contractures may be helpful, especially in younger patients; it should not be unduly delayed or trophic changes may develop and the general condition deteriorates. Neurectomy is not usually practised, but tendon lengthening and joint stabilization may be of great value. The deformity most frequently requiring correction is pes equino-varus for which lengthening of the tendo-Achillis and triple arthrodesis may be performed (p. 461). Both operations can be carried out at the same time and it is often possible to restore useful function to an otherwise bed-ridden or chair-ridden patient.

## THE HEREDITARY ATAXIAS

This group of diseases, of which *Friedreich's ataxia* is the commonest, is due to sclerosis of the posterior and lateral columns of the spinal cord. In some families the disease breeds true and one parent and some of the offspring have an identical affliction, but in other families the manifestations and course vary even in the same generation.

The age at onset varies from early childhood to early adult life. The severity of the disease also varies from a minor difficulty in co-ordination to complete incapacity. The principal symptoms are ataxia due to muscular inco-ordination which causes an irregular swaying gait, choreiform movements of the arms, and nystagmus. The tendon reflexes disappear, the ankle jerks usually being lost before the knee jerks, and the plantar responses are upgoing. The limbs may be hypotonic or slightly spastic.

The orthopædic interest is chiefly in the deformity of the feet which occurs when the pyramidal tracts are involved. The characteristic deformity develops early, often before the deep reflexes have changed. It consists of pes equinus with a superimposed pes cavus and clawing of the toes, especially the big toes. Scoliosis is present in a few patients when the muscles of the trunk are affected to a different extent on the two sides.

Operative correction of the deformity of the feet is more satisfactory when the onset is early than when it is late. The tendo-Achillis usually requires lengthening, and Lambrinudi's arthrodesis of the interphalangeal joints of the toes, if performed not later than fourteen or sixteen years of age, may prevent pes cavus developing (p. 230). When the onset is late, the patient may have to be content with surgical shoes and appropriately moulded insoles.

## OBSTETRICAL PARALYSIS

This is an unfortunate complication of child-birth in which there is partial or complete palsy of one arm, and rarely of both arms. It is caused by injury to the brachial plexus, a finding that has frequently been confirmed at operation. When the head is inclined and rotated to one side, the brachial plexus of the opposite side is stretched. Injury occurs, usually during the course of a difficult or prolonged labour, as the result of traction on the head, trunk or arm whilst the neck is bent sideways and twisted. The percentage of breech presentations complicated by obstetrical paralysis is higher than the percentage of head presentations, but since head presentations are much more common, the total number of obstetrical paralyses following them is four times as great as after breech presentations.

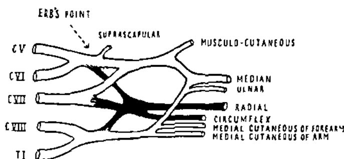



Fig 363 The brachial plexus

Damage to the brachial plexus may be of any degree of severity. In the less severe injuries, the nerve fibres are damaged in continuity and considerable recovery is probable (*axonotmesis*), but in the most severe injuries the nerve trunks are ruptured completely, or the nerve roots are avulsed from the spinal cord, and there is no possibility of spontaneous recovery (*neurotmesis*). Many injuries are of intermediate severity, some of the nerve bundles being damaged in continuity, and some being ruptured; partial recovery is then likely, but perineural hæmorrhage and subsequent scar formation may exert sufficient pressure on the plexus to prevent extensive regeneration.

### Types

Three types are described, but they are often mixed.

**Upper Arm** (*Erb-Duchenne*). At least three-quarters of all obstetrical palsies are of this type. The injury is at the junction of the anterior primary divisions of the fifth and sixth cervical roots (Erb's point, Fig. 363). The muscles chiefly affected are the deltoid, supraspinatus, infraspinatus, teres minor, *part of the pectoralis major, the biceps and the supinator* longus, and sometimes the extensors of the wrist and fingers.

**Lower Arm** (*Klumpke*). This type is rare as an isolated occurrence. Only the eighth cervical and the first dorsal roots are involved, and the muscles affected are the flexors of the fingers and the intrinsic muscles of the hand. In addition, the sympathetic nerve fibres may be damaged

causing narrowing of the palpebral fissure and reduction in the size of the pupil.

**Whole Arm.** The entire brachial plexus is ruptured, the arm is flaccid and there is complete sensory loss.

## Clinical Features

Injuries of the upper arm and whole arm types are usually noticed soon after birth, but in lower arm palsies the most obvious sign is loss of the "grasp reflex" and this may be overlooked for a time.

**Upper Arm.** In a classical example of upper arm paralysis the arm lies with the shoulder adducted and rotated inwards, the elbow extended,



Fig 364. Obstetrical palsy of upper arm type

the forearm pronated, and the palm of the hand facing backwards (Fig. 364). Spontaneous active movements are conspicuously absent, and passive movements of the shoulder are painful. There is tenderness above the clavicle, and sometimes a swelling due to hæmorrhage. The differential diagnosis is from fracture of the humerus or clavicle, and separation of the upper epiphysis of the humerus.

Some recovery often takes place during the first few months; it is usually gradual, occasionally rapid, and only rarely is it complete. Contractures develop rather quickly because of the unbalanced action of the muscles, and the shoulder becomes fixed by contraction of the subscapularis and anterior portion of the capsule in a position of adduction and internal rotation. In time the head of the humerus may subluxate backwards over the rim of the glenoid fossa and then the shoulder is partly flexed and the arm adducted across the chest. When the forearm extensors are paralysed, the wrist and fingers are held strongly flexed and the hand is useless.

## Treatment

**Conservative.** Time must be given to allow the greatest amount of spontaneous recovery to take place, but contractures must be prevented meanwhile and therefore the arm placed in a position of abduction and external rotation. This is most easily and safely arranged in very young

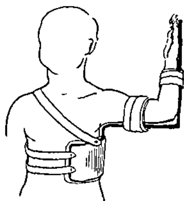


FIG 365

babies by tying the wrist with a flannel bandage behind the neck to the opposite shoulder. This method may be used until the baby is sitting up and then a splint may be substituted. Temporary splints can be home-made from Kramer wire, but for older children an aluminium splint is preferable (Fig. 365). The splint is taken off each day when the baby is washed and the limb is moved to prevent stiffness. The use of a splint is continued, at any rate for part of the day, for two or three years, and thereafter regular passive movements through the full range should be sufficient to prevent contractures.

If there has been some recovery, much can be done to improve function by encouraging the use of the limb, particularly of the weaker muscles. The child often has the muscle power to make a particular movement but does so in an uncertain manner because of deficiency in proprioceptive sensibility. He therefore prefers to do most things with the unaffected hand alone and it requires no little ingenuity, and the utmost patience on the part of parents and physiotherapists, to devise entertaining ways of persuading him to use the affected limb. Some children tolerate having

the good hand tied to the body part of the time, but this should not be done if it is seriously resented; it causes less upset if started very young, a few months after birth. Galvanic stimulation of the paralysed muscles is probably worth while for as long as improvement continues.

**Operative.** Repair of the brachial plexus has been attempted many times but only on rare occasions has it been rewarded with a worth-while result. The nerve ends are frayed and ragged, and even if they can be approximated, the amount of perineural scarring is usually so great as to prevent regeneration. Operation is unnecessary if there is appreciable spontaneous recovery; if there is no recovery after a year or two and the paralysis is extensive, exploration may be justifiable because it offers the only hope of improvement.

Contractures at the shoulder in infants can usually be corrected by manipulation under anæsthesia followed by fixation in a plaster-of-Paris spica. In older children, particularly when the function of the hand is good, open division of the contracted tissues may be desirable. In *Fairbank's operation* the shoulder is approached through an anterior incision and the tendon of the subscapularis muscle and the joint capsule are divided; sometimes it is necessary to divide also the teres major and latissimus dorsi, and occasionally a "beaked" acromial process requires removal.

# INDEX

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